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ABSTRACT

This book offers an introduction to the history and nature of science and technology (HNST) for educators who are interested in teaching about this content area. The book has five chapters, organized to address the following questions: (1) Why is this subject matter important?; (2) What should be taught about this subject matter?; (3) How can I get started teaching about this subject matter when I am not an expert myself?; (4) What pedagogical approach is best to use?; and (5) What materials are available for teaching about this subject matter? Chapter 1 helps interested teachers understand why incorporating HNST into science and social studies courses is beneficial to students. Chapter 2 presents the six themes from the HNST curriculum framework. Chapter 3 demonstrates how to get started with HNST. Chapter 4 briefly introduces the constructivist approach to teaching and presents exemplary HNST lessons with concrete materials to try in the classroom. Chapter 5 provides sources of information and materials. (EH)

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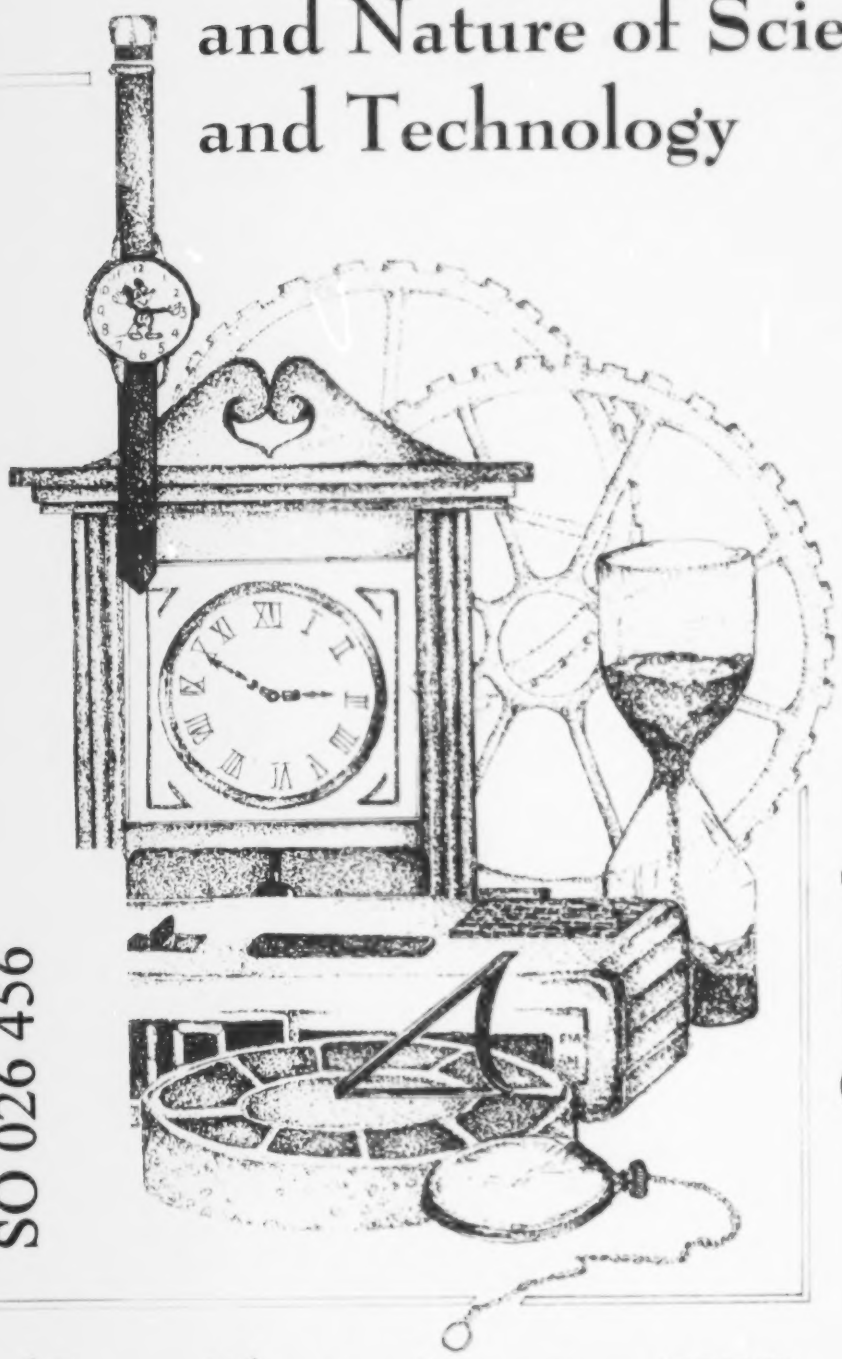
# Teaching About the History and Nature of Science and Technology



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## Teacher's Resource Guide

SO 026 456

Social Science Education Consortium (SSEC)
Biological Sciences Curriculum Study (BSCS)



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# Teaching About the History and Nature of Science and Technology:

# Teacher's Resource Guide

1996

A Collaborative Project of
Social Science Education Consortium (SSEC) and
Biological Sciences Curriculum Study (BSCS)

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# INTRODUCTION

The importance of history to the study of science and technology and the importance of science and technology to the study of history have been recognized in numerous reform efforts currently underway in American schools. But what are teachers not specifically trained in the history and nature of science and technology to make of these recommendations? How can they work through such questions as:

- Why is this subject matter important? Will exploring this content help students achieve the objectives I have set for my courses?
- What should I teach about this subject matter? What "big ideas" about the history and nature of science and technology should my students learn?
- How can I get started teaching about this subject matter when I am not an expert myself? Can this content only be taught in interdisciplinary units or courses?
- What pedagogical approach should I use? What kinds of lessons or units might I develop?
- What materials are available for teaching about this subject matter? How can I learn more about it myself?

Because we recognize that answering these questions can be difficult, for the past several years, BSCS (Biological Sciences Curriculum Study) and SSEC (Social Science Education Consortium), with the support of the National Science Foundation, have been collaborating to make teaching about the history and nature of science and technology easier.

## The BSCS/SSEC Collaboration

In the first phase of our collaboration, which took place from 1989-1991, the two organizations produced *Teaching About the History and Nature of Science and Technology: A Curriculum Framework*. At the core of the framework are six conceptual themes designed to be organizers for teachers' use in selecting content about the history and nature of science and technology or in bringing coherence to what they already teach about these topics.

After the framework was completed, SSEC and BSCS embarked on a leadership development project, in which ten teams of educators from around the country participated. In summer 1993, the ten teams attended a four-week institute focusing on teaching about the history and nature of science and technology. At the institute, they developed curriculum units that they implemented in their classrooms during the 1993-94 school year. In 1994, they returned to Colorado for a two-week institute focusing on how to share what they learned about teaching HNST with colleagues during the 1994-95 school year. SSEC and BSCS staff developed this volume for participants' use in conducting staff development activities in their home districts.

## Organization of This Volume

This book offers an introduction to the history and nature of science and technology (HNST) for educators who are interested in teaching about this content area. It includes and expands on the substance of the *Curriculum Framework*, which is no longer available. The book has five chapters, organized to help you work through the questions we listed above.

- **Chapter 1** is intended to help interested teachers understand why incorporating HNST into science and social studies courses is beneficial to students. We argue that teaching about HNST enhances students' cultural, scientific, and technological literacy, and we connect HNST to the national standards.
- **Chapter 2** presents the six themes from the HNST curriculum framework. Our goal is to make the themes concrete and meaningful by providing a brief sampling of lessons and activity ideas exemplifying the themes.
- For teachers who are interested in HNST and see the themes as useful organizers but don't quite know what to do next, **Chapter 3** will demonstrate how they can get started with HNST. The chapter provides numerous planning tools and examples to help teachers think through what and how they will teach about HNST.

- **Chapter 4** very briefly introduces the constructivist approach to teaching, an approach that we recommend. The chapter then presents a number of exemplary HNST lessons that provide teachers with some concrete materials they can try in their classrooms.
- **Chapter 5** provides sources of information and materials. Materials and resources suitable for classroom use are listed, as are references for teachers' professional development. The listing is not comprehensive but should provide a good starting place for teachers.

Because we think that most teachers will want to consider the why and what questions first, those are the topics we deal with in Chapters 1 and 2. However, if you want to think first about practical topics, like how you might get started teaching about this subject area, you could start with Chapter 3 of the book, referring to the chapters on rationale and themes as needed. If you like to start with very concrete ideas, you could browse through the sample lessons in Chapter 4 first to get a sense of how HNST might look in the classes you teach; you could then return to Chapter 1 to begin working through the planning process. In essence, we would urge you to use the materials and tools in this book however they will be most useful as you explore the possibility of integrating the history and nature of science and technology in your curriculum.

CHAPTER 1

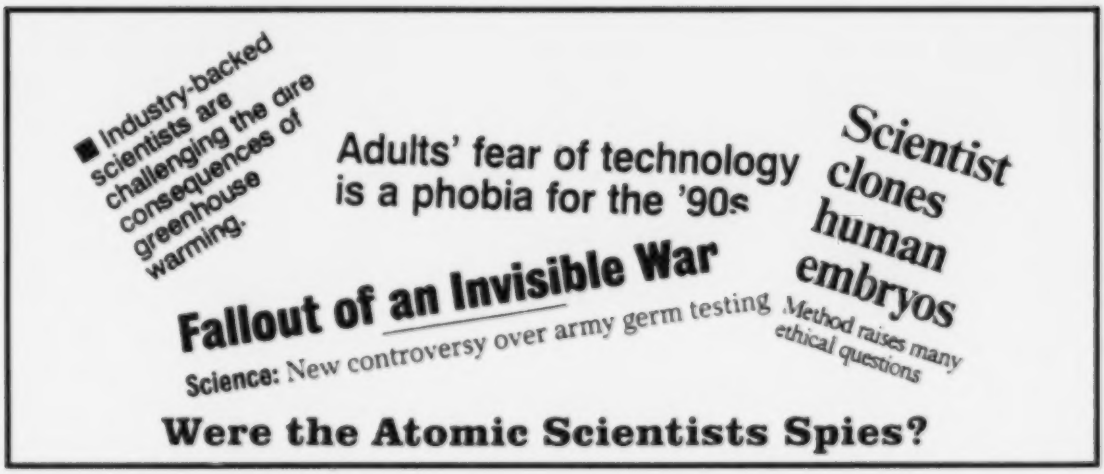
# A Rationale for Teaching About the History and Nature of Science and Technology

*Susan, a student in Ms. Gibbs's American history class, raised her hand on Monday morning to ask about a disturbing story she'd read in the newspaper over the weekend. Susan related the story of plutonium testing conducted on U.S. citizens in the 1940s. During the tests, doctors injected plutonium into unsuspecting people, under the guise of a new treatment for illness. At least 18 people were injected with plutonium as part of a top-secret government experiment that began as the United States entered the atomic age. Scientists, concerned about the safety of workers in the nuclear industry, sought information on how the human body excreted plutonium. In spring 1994, the U.S. Energy Secretary apologized to surviving relatives of the plutonium test victims. "How," Susan asked, "could the government support this kind of research?"*

*Ms. Gibbs replied that perceived or real risks to national security, such as that posed by the Soviet Union at the onset of the Cold War, could affect the judgment of policy makers as well as scientists. Later that day, Ms. Gibbs considered Susan's question and her answer to it in more depth. Susan's concern could serve as the springboard for a class study of the conduct of science in the Cold War era. As Ms. Gibbs saw it, the unit would explore such themes as the relationships between government-sponsored scientific and technological research, the political and military contexts for such research, and its impacts on ordinary Americans. Ms. Gibbs resolved to talk with her colleagues in the science department to seek supporting ideas.*

This contemporary news story about plutonium testing, and Susan's strong reaction to it, reflect the importance of teaching about issues related to the history and nature of science and technology (HNST): What is the relationship between science and technology? How do human values interact with both enterprises over time? What is the influence of culture, in this case government and military policy, on the conduct and content of science.

Emerging science and history education standards emphasize the importance of teaching about these very issues, but with large course loads and already lengthy syllabi, why should American educators add teaching about the history and nature of science and technology to their curriculum? Why should secondary students be knowledgeable about themes and issues related to the historical development of science and technology? The plutonium experiment case suggests one answer: to be informed and responsible citizens we must be able to recognize societal and cultural influences on the conduct of science and technology. The second and larger answer is that we cannot understand our advanced technological society without understanding the history and nature of science and technology; nor can we fully comprehend science and technology without understanding their historical roots and interactions. In short, we cannot be truly culturally or scientifically literate without knowledge of the history and nature of science and technology.


Industry-backed scientists are challenging the dire consequences of greenhouse warming.
Adults' fear of technology is a phobia for the '90s
Scientist clones human embryos
Fallout of an Invisible War
Science: New controversy over army germ testing
Method raises many ethical questions
Were the Atomic Scientists Spies?

## HNST and Cultural Literacy

American schools require some study of history so that students will be knowledgeable about the development of our culture. Melvin Kranzberg, professor of the history of technology at the Georgia Institute of Technology, argues that we must specifically address technology in our study of history if we are to truly understand our culture:

> Although historians might write loftily of the importance of historical understanding by civilized people and citizens, many of today's students simply do not see the relevance of history to the present or to their future. I suggest that this is because most history, as it is currently taught, ignores the technological element. Our students know that they live in a technological age, but any history that ignores the technological factor in societal development does little to enable them to comprehend how their world came into being (Kranzberg 1986, p. 554).

Similarly, educator Russell Hvolbek argues for the inclusion of the history of science in pre-collegiate education:

> To understand the modern world requires a knowledge not simply of science but of the history of science. To learn how nature works is to learn science; to learn how the theories of science have molded our conceptions of reality is to learn history. The one offers command over nature, the other offers comprehension of the world human beings have made through their investigations and theories. An understanding of the history of science is essential if students are to have a grasp of the modern world and how it evolved (Hvolbek 1993, p. 384).

To comprehend our culture, then, students need to understand how science and technology have helped to shape it. These issues can be addressed in a wide range of courses. For example, the physics teacher who encourages students to explore not only what Newton's laws are but how acceptance of Newton's mechanical model of the universe shaped people's views is addressing an important aspect of cultural literacy, as is the history teacher whose students reenact the Scopes trial to investigate the impact of Darwin's theory of human evolution on American society. Through such explorations, students see that the human enterprises of science and technology have helped to determine how we interact with one another and our environment, and even what it means to be human.

## HNST and Scientific and Technological Literacy

What does it mean to be scientifically and technologically literate? Scientific literacy is not merely an acquaintance with chemical formulas and physical equations. It is an awareness of science as an evolving process of acquiring knowledge, a way of knowing and understanding ourselves and our world. Throughout human history, from Copernicus's astronomical investigations to the Human Genome Project, the pursuit of scientific knowledge has altered the way we think about human life and our role in the universe.

Technological literacy involves understanding technology as a human effort to adapt to our world. In *Science for All Americans*, authors F. James Rutherford and Andrew Ahlgren describe this effort:

> As long as there have been people, there has been technology. Indeed, the techniques of shaping tools are taken as the chief evidence of the beginning of human culture. On the whole, technology has been a powerful force in the development of civilization, all the more so as its link with science has been forged. Technology—like language, ritual, values, commerce, and the arts—is an intrinsic part of a cultural system and it both shapes and reflects the system's values (Rutherford and Ahlgren 1989, p. 39).

Scientific and technological literacy enables us to understand science and technology as human activities that have interacted through time, that form a part of our culture, and are affected by culture. In the science classroom, students can appreciate the interactions between science and technology by studying Galileo's reconstruction of a new technology, the telescope, that allowed him to discover solar spots, Saturn's "satellites," and other marvels of the sky. In the social studies classroom, students can explore the impact of technology on society by examining the surprising consequences produced by "time-saving" household technologies. Through such explorations, students better understand the historical interactions between science, technology, and society.

Understanding science and technology, then, means not only knowing scientific theories, scientific methods, and how to navigate in a car or through menu-driven software; it means being knowledgeable about the history and nature of science and technology: understanding that science, technology, and society have interacted throughout human history; that scientific investigations and technological developments do not occur in isolation from human values. This kind of knowledge helps students like Susan understand their own society, past and present; it encourages students to make connections across the curriculum; it enables them to be more thoughtful users and creators of technology. Teaching about the history and nature of science and technology provides opportunities for teachers and students to collaborate and share ideas about issues that are fundamental to our society: who we are, how we got this way, and where we are going.

## Support for HNST in the National Standards

The compelling arguments for teaching about the history and nature of science and technology are reflected in the national standards recently developed by leading groups in the various academic disciplines, which support inclusion of this content in both the science and social studies curricula. Inclusion of HNST topics and ideas in these standards, which are expected to have a substantial impact on curricula in school districts nationwide, provides another reason for teachers to begin integrating HNST into their courses.

The connections between HNST and the standards are very clear in the *National Science Education Standards* (National Research Council 1996). This document identifies eight categories of content standards, four of which are directly related to the history and nature of science and technology:

- Science as inquiry.
- Science and technology.
- Science in personal and social perspectives.
- History and nature of science.

Table 1.1 indicates specific content standards for secondary grade levels in each of these strands; connections to HNST are once again obvious.

In social studies, the situation is complicated by the numerous sets of standards that have been promulgated. In addition, because science and technology are just two of the many human systems that provide the subject of study, explicit references to the history and nature of science and technology are not frequent. In each current set of standards—integrated social studies, geography, history, and civics—connections can be seen, however. Clearly, examples drawn from the history and nature of science and technology can be useful in developing a wide array of understandings identified as critical in the social studies standards documents.

The National Council for the Social Studies has developed a set of integrated social studies standards entitled *Expectations of Excellence: Curriculum Standards for Social Studies* (1994). Among the ten themes that provide the framework for these standards is "Science, Technology, and Society." Clearly, this theme deals with interrelationships among science, technology, and society—important aspects of understanding the history and nature of science and technology. In addition, HNST ideas and concepts can be useful in

# Table 1.1
# SCIENCE STANDARDS THAT SUPPORT HNST CONTENT

| Strand | Level 5-8 Standards | Level 9-12 Standards |
|---|---|---|
| Science as Inquiry | Abilities necessary to do scientific inquiry<br>Understanding about scientific inquiry | Abilities necessary to do scientific inquiry<br>Understanding about scientific inquiry |
| Science and Technology | Abilities of technological design<br>Understanding about science and technology | Abilities of technological design<br>Understanding about science and technology |
| Science in Personal and Social Perspectives | Personal health<br>Populations, resources, and environments<br>Natural hazards<br>Risks and benefits<br>Science and technology in society | Personal and community health<br>Population growth<br>Natural resources<br>Environmental quality<br>Natural and human-induced hazards<br>Science and technology in local, national, and global challenges |
| History and Nature of Science | Science as a human endeavor<br>Nature of science<br>History of science | Science as a human endeavor<br>Nature of scientific knowledge<br>Historical perspectives |

developing student understanding of such other themes as "Culture"; "Time, Continuity, and Change"; "People, Places, and Environments"; and "Production, Distribution, and Consumption."

Turning to the standards for the individual disciplines comprising the social studies, support for teaching HNST can also be found. For example, the geography standards (*Geography for Life* 1994) suggest that the geographically informed person knows and understands:

- How human actions modify the physical environment.
- How physical systems affect human systems.
- The changes that occur in meaning, use, distribution, and importance of resources.

Technology certainly plays a role in modification of the physical environment and is one of the human systems affected by the physical environment. Many other examples in which HNST content supports the geography standards can also be identified and used to enhance student achievement.

Similarly, a sample standard from the world history standards (*National Standards for World History* 1994) indicates HNST connections. One standard calls for students to demonstrate their understanding of the achievements of Olmec civilization by:

- Analyzing the relationship between maize cultivation and the development of complex societies in Mesoamerica.
- Interpreting archaeological evidence for the development of Olmec civilization in the second millenium BCE.
- Evaluating major Olmec contributions to Mesoamerican civilization, including the calendar, glyphic writing, sculpture, and monumental building.
- Assessing Olmec cultural influence on the emergence of civilization in the Oaxaca valley or other regions.

Each of these indicators involves understanding key ideas from the history and nature of science and technology.

Turning to the *National Standards for Civics and Government* (1994), we find a substantial emphasis on public policy formation and the role of citizen. Understanding the ethical dimensions of science and technology, as well as historical influences of these enterprises on society, can help students in their role as citizens more knowledgeably deal with public policy issues related to science and technology. Thus, HNST content is key to achieving the civics/government standards as well.

Thus, all of the major national standards documents of interest to science and social studies teachers provide support for teaching the history and nature of science and technology. HNST is, in fact, a major element of the science content standards and helps support teachers in their efforts to achieve standards in the social studies.

## Your Turn:

**1. Susan's concern about the plutonium testing story and Ms. Gibbs's response illustrate how news stories about science and technology can provide rich opportunities for addressing HNST themes in the classoom. Look at today's newspaper. What stories can you identify about science and/or technology that involve human values or a historical context?**

**2. Using the same news stories, choose one that you can connect to your teaching assignment. How does this story further students' cultural, scientific, and technological literacy?**

## References

*Expectations of Excellence: Curriculum Standards for Social Studies* (Washington, DC: National Council for the Social Studies, 1994).

*Geography for Life: National Geography Standards* (Washington, DC: National Geographic Society, 1994).

Hvolbek, Russell H., "Teaching the History of Science," *Social Education* (November/December 1993).

Kranzberg, Melvin, "Technology and History: 'Kranzberg's Laws'," *Technology and Culture*, vol. 27 (July 1986).

National Research Council, *National Science Education Standards* (Washington, DC: National Academy Press, 1996).

*National Standards for Civics and Government* (Calabasas, CA: Center for Civic Education, 1994).

*National Standards for World History: Exploring Paths to the Present, Grades 6-12 Expanded Edition* (Los Angeles: National Center for History in the Schools, UCLA, 1994).

Rutherford, James, and Andrew Ahlgren, *Science for All Americans* (Washington, DC: American Association for the Advancement of Science, 1989).

Welsome, Eileen, "Six More Test Victims Revealed," *The Albuquerque Tribune*, March 5, 1994, p. 1.

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CHAPTER 2

# An Introduction to the Themes for Teaching the History and Nature of Science and Technology

To assist educators in teaching about science and technology across the curriculum, we have identified six conceptual themes. These themes have been designed for general use in organizing curriculum and instruction throughout the elementary-secondary curriculum. For the sake of introduction, each theme is presented independently. However, you will quickly recognize the interrelated, overlapping nature of the themes. The final section of the chapter therefore provides a sampling of lesson, activity, and unit ideas appropriate for integrating and addressing the six themes in secondary science and social studies classrooms. These curriculum ideas are designed to help you begin thinking about practical applications of the themes while illustrating their interrelated nature.

## The Themes

### *Theme 1: Science is a way of explaining the world.*

Throughout history, humans have sought to understand and explain themselves and the natural world. Science can be defined as a process of questioning, testing, and explaining the world.

Science begins with a question about natural phenomena. The scientific question can be as simple as a child's curiosity about where the dinosaurs went or why the sky is blue. Or, the question can be as complex as the scientists' inquiries into the process of extinction or the chemistry of ozone depletion.

Once such a question is asked, the process of scientific inquiry begins, and there eventually may be an answer or a proposed explanation. Scientific inquiry is characterized by curiosity, freedom to pursue that curiosity, creativity, skepticism, tolerance for ambiguity, and openness to new knowledge.

Scientific inquiry includes systematic approaches to collecting information, observing, identifying significant variables, formulating and testing hypotheses, and measuring precisely, accurately, and reliably. Understanding and designing experiments and obtaining appropriate measurements also are part of the inquiry process. Once data have been acquired, they must be organized, summarized, and interpreted in meaningful ways. Examples of data summaries include taxonomy of organisms, the periodic table of elements, and the classifications of rocks and minerals.

While it is simply a humorous vignette, the Calvin and Hobbes cartoon in Figure 2.1 actually embodies a number of the fundamental elements of the scientific process that we have just discussed. In the comic strip, the boy articulates the essence of science as curiosity—asking questions and seeking explanations for natural phenomenon. He then goes on to form a hypothesis and

CURIOSITY IS THE ESSENCE OF THE SCIENTIFIC MIND.
FOR EXAMPLE, YOU KNOW HOW MILK COMES OUT YOUR NOSE IF YOU LAUGH WHILE DRINKING?
WELL, I'M GOING TO SEE WHAT HAPPENS WHEN I INHALE MILK INTO MY NOSE AND LAUGH!
IDIOCY IS THE ESSENCE OF THE MALE MIND.
I'M GUESSING IT WILL SHOOT OUT MY EARS. DON'T YOU WANT TO SEE?

Calvin and Hobbes © 1993 Watterson. Reprinted with permission of United Press Syndicate. All rights reserved.

**Figure 2.1**

test it through experimentation. Another important element embodied in this Calvin and Hobbes scenario is that one doesn't need to be a formally trained scientist to engage in scientific inquiry.

Scientific explanations are more than the results of collecting and organizing data. The important processes of constructing laws, elaborating models, and developing theories based on data extend, clarify, and unite the observations and data and, very importantly, develop deeper and broader explanations.

One abiding characteristic of scientific explanations is that they are in a continual state of change. Two types of changes occur in scientific explanations. First, new explanations are developed; second, old explanations are modified.

Just because someone asks a question about an object, organism, or event in nature does not necessarily mean that person is pursuing a *scientific* explanation. In modern, Western science, there are *rules* that make some explanations scientific. Some of the rules that make explanations scientific include the following.

1. Scientific explanations must follow from observations that are based on sensory experiences, or an extension of the senses through technology.

2. Scientific explanations must be made public and subjected to scrutiny.

3. Scientific explanations are tentative; in other words, they are subject to modification as more is learned about the phenomenon.

4. Scientific explanations are historic, evolving from past explanations.

5. Scientific explanations are often probabilistic, based on a statistical view rather than an absolute view of nature.

6. Much of science is directed toward determining causal relations and developing explanations for linkages between events.

While science is an essential way of understanding the world, it cannot, and does not, provide answers to all humans' questions. Some questions, such as the meaning of life, or questions within the realm of ethics or religion, cannot be answered by science because they cannot be answered through empirical observations. Moreover, the pursuit of scientific explanations inescapably creates new questions, and the use of scientific knowledge inevitably has unintended consequences.

A number of focus questions may assist teachers in developing student understanding of theme 1:

- What is science?
- What is a good scientific explanation?
- How do scientists do their work?
- How do scientists use inference in developing scientific explanations?
- What are the limits to science?
- What values are important to science?

***Theme 2: Technology is a way of adapting to the world.***

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**Figure 2.2**

The pursuit of technological innovations originates with problems humans have in adapting to the environment and results in proposed solutions to those problems. Stated another way, humans use technology to change their environment. The changes relate to different human needs. Humans need protection and food, and they need to move objects and information. The person in the cartoon in Figure 2.2 has clearly solved a transportation problem. His plans for the round technology he is transporting are less clear. Solving these problems through the building and application of tools is the simplest example of technology as a way of adapting to the world. Development and use of agriculture, weapons, ships, and the telegraph illustrate more complex levels of technology.

When considering technological solutions, an individual considers, either directly or indirectly, such factors as availability, strength and durability of materials, scientific laws, and human dimensions of the problem. Other issues, such as cost, performance criteria, aesthetics, and efficiency, also may be considered. Engineers, for example, often assess trade-offs among constraints and other possibilities before making their decisions about the best solution for a particular problem.

Many features of science also apply to technology—curiosity, creativity, aesthetics, use of logic, and abstract reasoning. There are also differences. Scientists try to understand the world, and technologists (engineers) try to adapt or control the world. Scientists try to develop explanations that are generalizable, while engineers develop solutions to specific problems. Scientists try to show that explanations fit observations, and engineers try to show that designs work. Just as scientists cannot answer all questions, engineers cannot solve all problems.

Although scientific inquiry and technological problem solving have many common elements, such as observation and use of data, technological problem solving is distinguished from science by unique factors, such as consideration of cost, risk, and benefit, and optimization and efficiency. Technological solutions often, if not always, are judged by their being workable, applicable, aesthetically pleasing, and feasible. Technological solutions, like scientific explanations, are subject to change. The pursuit of technological solutions inescapably creates new problems, and the application of technology inevitably has unintended consequences. Characteristics of technological problem-solving include the following.

1. Technological solutions are based on pragmatic criteria.

2. Technological solutions must be developed within natural constraints.

3. Technological solutions exist within human constraints.

4. Technological solutions involve control.

5. Technological solutions have side effects.

6. Eventually, technological devices fail.

In the classroom, teachers can guide students to an understanding and appreciation of theme 2 through such focus questions as:

- What is technology?
- What are the values associated with technology?
- What are the characteristics of a good technological solution?
- What is the nature of technological knowledge?
- What are the limits and possibilities of technology?
- What are potential risks and benefits of a particular technology?

### *Theme 3: Science and technology are activities that involve human values.*

Certain values are necessary for science and technology to survive and flourish. Methods of inquiry in science are embedded in a network of values, attitudes, and assumptions about knowledge—what it is and how it is produced.

Fundamental to the practice of science is the belief that seeking and producing knowledge about the physical world are worthy human endeavors. Scientists recognize that knowledge changes over time and that, as data suggest different explanations, they must be willing to revise previous explanations. Moreover, scientists recognize that data are value laden and that a single body of data may logically support more than one conclusion, just as different bodies of data may support a single interpretation. Inferences from data are made by humans and, therefore, are fallible constructions. As such, scientists must be skeptical and critical, willing to view conclusions as tentative.

Understanding these values, attitudes, and assumptions is likely to foster appreciation of what science is and is not and to stimulate reflection, which transcends the boundaries of scientific inquiry, about the social uses of science—about the central question of philosophers and responsible citizens: To what end?

Similarly, values underlie the technological enterprise. Technology is founded on the assumption that problems can be solved and that finding solutions is a worthwhile undertaking. Further, the character of technological problem solving is based on the assumption that nature can be controlled or transformed for practical reasons. Because all technologies have unintended effects, acceptance of risk is another attitude crucially linked to technology.

Characteristics of persons engaged in scientific inquiry and technological problem solving are linked to the values, attitudes, and assumptions of these enterprises. Science and technology rely upon such personal characteristics as curiosity, prudence, patience, creativity, cooperation, and perseverance, but they are sometimes corrupted by vanity, greed, and deceit.

While science and technology interact with society, they present individuals within the enterprise and people outside the enterprise with a changing array of ethical issues. The pursuit of scientific explanations and technological solutions may conflict with individual or societal values—equality, justice, peace, liberty—requiring citizens to reason about these conflicts. In the United States, citizens have the freedom and responsibility to participate in policy decisions related to science and technology. Experts, such as scientists and engineers, are called upon to inform citizens and policymakers, but the limits of expertise are recognized.

Figure 2.3 presents a joking look at a real ethical or value dimension of contemporary science and technology—the use of alternative medicines and medical treatments. Poking fun, the cartoon implies that the only dilemma involved in alternative medical treatment is the issue it raises of potential lost income for doctors. In fact, while many alternative medicines have exciting potential and show medical results, they may not have undergone the same scientific testing as conventional medical therapies. Thus, questions are of how, when, and whether to offer patients alternative treatments.

In the classroom, the following focus questions can guide the study of theme 3:

- What values are inherent in *scientific method*?
- What are the major values associated with science and technology?
- How might individual and societal values influence the conduct and content of scientific and technological pursuits?
- How should conflicts between scientific or technological pursuits and other values be resolved?

*"I have no objection to alternative medicine so long as traditional medical fees are scrupulously maintained."*

Drawing by Mankoff; © 1993
The New Yorker Magazine, Inc.

**Figure 2.3**

***Theme 4: The social, cultural, and environmental contexts within which they occur influence the conduct and content of science and technology.***

Arkansas Democrat-Gazette, John Deering.

**Figure 2.4**

Neither science nor technology would exist if people did not create them. Creativity is essential to innovations in both technology and science, yet social and economic forces greatly influence which science and technology will be undertaken, embraced, invested in, and utilized. Like other aspects of culture, science and technology reflect the experiences, perceptions, concerns, goals, and world views of the people who develop them.

Take a look at Figure 2.4, which pokes fun at the 1980s-1990s debate over protection of the spotted owl in the Pacific Northwest. How did the economic factors and contemporary environmental attitudes and concerns in the United States create this controversy? How did social, economic, and environmental factors influence government action on lumbering?

In trying to understand the relationships between both science and technology and the contexts within which they occur, one is immediately struck by the fact that all people, across time, place, and culture, seek explanations for natural phenomena and technological means to achieve some of their goals. Indeed, the potential for science and invention is evident throughout humankind. Some individuals have greater inventive skills than others, and societies and cultures may pursue different avenues of science and technology to different degrees. Yet no group of people has a monopoly on scientific or technologic creativity.

Because natural resources and other environmental factors vary greatly from place to place and from time to time, and because human values and tastes differ so much from culture to culture, there is diversity among the scientific explanations and technologic solutions that different people have adopted and used. These inventions and conventions are illustrative of the diverse ways in which men and women throughout time have chosen to define and pursue existence. The context of these diverse definitions profoundly influence the science and technology that particular people develop at particular times. In short, students should be exposed to the idea that science and technology should be studied as parts of complex cultural matrices that include socially defined ends, means, and values.

Several focus questions may help to clarify and elaborate theme 4, while providing a guide for curriculum infusion:

- Historically, how has society or cultural context influenced the questions that scientists ask and the problems that scientists and technologists decide to pursue? Are these social and cultural influences still present or are science and technology universal at the end of the 20th century?
- Historically, what influences have society and culture had on the acceptance or rejection of scientific explanations and technological solutions?
- Can individuals or groups within a society influence the course of science and technology? How so?
- What have been and what are the relationships among gender, race, ethnicity, class, and the conduct and content of science and technology?
- Who, if anyone, controls science and technology? Is this relationship the same across cultures? Through time?

### *Theme 5: Science and technology influence the social, cultural, and environmental contexts within which they occur.*

The comic strip situation in Figure 2.5 satirizes our society's fascination with and dependence on innovative, high technology communications. "Dilbert" seems to firmly believe that the proliferation of new technologies has improved the ways we communicate and do business, even while these new technologies are complicating his life to the point that he can't pass on the information he has. This cartoon captures several of the important concepts embodied in theme 5: science and technology influence the social, cultural, and environmental contexts within which they occur.

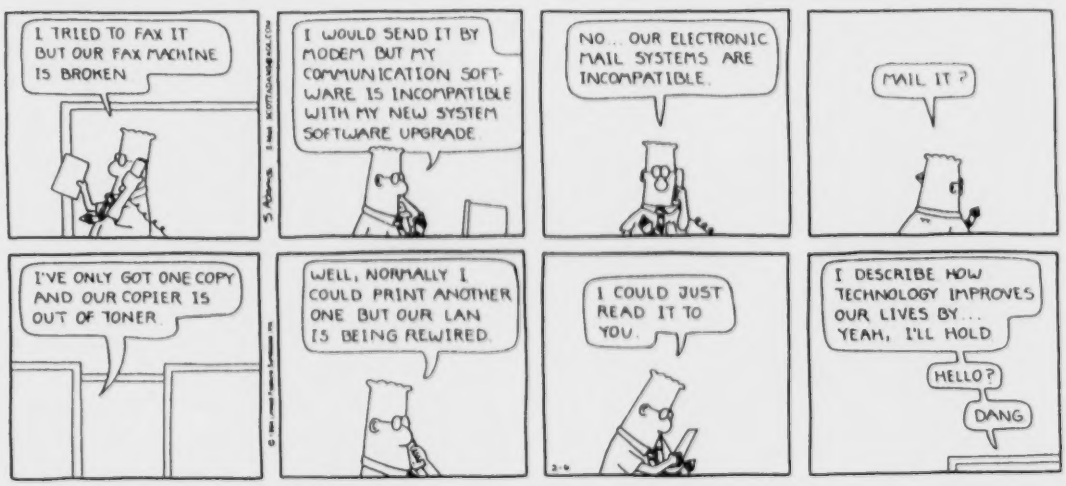
Just as social organization, cultural values, environment, and resources influence the conduct and content of science and technology, so is there a reciprocal influence of science and technology on society, culture, and environment. Many times these influences are intended consequences of an invention, but science and technology also have unintended effects—sometimes harmful, sometimes beneficial. Dilbert's dilemma in Figure 2.5 is just one illustration of this point. The effects of science and technology usually do not affect all individuals and groups similarly or equally.

The effects of science and technology are often difficult to predict. Increasing awareness of the differential effects of science and technology has led to mobilization of substantial resources to better predict the effects of technological innovations and scientific advances and therefore to minimize the potential risks involved.

Just as the differential effects of science and technology may be seen within individual societies or across geographic environments, so too they may be seen in situations in which a technologic or scientific practice is transferred from one society to another. For instance, historically, there have been instances when technology has been forced upon a recipient culture as part of the economic and political colonialism of some nations. The effects of these technologies proved to rest differently on different people within the receiving society, depending on their caste, class standing, or racial or ethnic group membership.

Several focus questions may help to elaborate and clarify theme 5, while providing a guide for lesson development and classroom discussion:

- To what extent are the consequences of science and/or technology intended or unintended?
- Do science and technology affect different people in different ways? How so?
- How are science and technology used differently by different people or groups, either within or across societies?
- How do science and technology affect the environment?


I TRIED TO FAX IT BUT OUR FAX MACHINE IS BROKEN.
I WOULD SEND IT BY MODEM BUT MY COMMUNICATION SOFTWARE IS INCOMPATIBLE WITH MY NEW SYSTEM SOFTWARE UPGRADE.
NO.. OUR ELECTRONIC MAIL SYSTEMS ARE INCOMPATIBLE.
MAIL IT?
I'VE ONLY GOT ONE COPY AND OUR COPIER IS OUT OF TONER.
WELL, NORMALLY I COULD PRINT ANOTHER ONE BUT OUR LAN IS BEING REWIRED.
I COULD JUST READ IT TO YOU.
I DESCRIBE HOW TECHNOLOGY IMPROVES OUR LIVES BY... YEAH, I'LL HOLD
HELLO?
DANG

DILBERT reprinted by permission of UFS, Inc.

**Figure 2.5**

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### *Theme 6: Science and technology have reciprocal effects and their interrelationships vary from time to time and place to place.*

In the present, as in the past, the connections between science and technology have been complex and never exclusively hierarchical. Technology is as old as humankind and is, arguably, older than science. Stone tool manufacture, for example, flourished for millions of years before the emergence of the science of mineralogy or geology. The basis for much technological know-how was trial and error; experience taught the craftsperson that certain materials and techniques produced acceptable results while others did not. Largely unaided by scientific knowledge, technologists continued in this manner at least until the 19th century.

During the scientific revolutions of the 16th and 17th centuries in Western Europe, technology played a great role in helping scientists begin to observe more acutely and to measure more precisely the phenomena they sought to understand. The myriad instruments that were important in the scientific revolution—for example, the telescope and thermometer—were produced by craftsmen. After the middle of the 19th century, science began to exert a significant influence on technology. For example, advances in understanding such phenomena as electricity and chemistry produced great technological activity and a resulting welter of devices and systems.

Despite the stimulus science began to exert on technology, the two enterprises remained remarkably distinct. Both science and technology became increasingly professionalized during the second half of the 19th century. While both shared reliance on scientific method and increasingly rigorous scientific doctrine, they developed as two distinct professional cultures.

During the 20th century, the structure, methods, and scope of technology have changed. These changes have been marked by the increasing erosion of the craft basis of technological activity. By the mid-20th century, technology had become thoroughly professional and increasingly specialized. Such structural changes have tended to bring science and technology more closely together.

Considered together, Figures 2.6 and 2.7 reflect some aspects of the changing relationship of science and technology over time. Gary Larson's "Far Side" cartoon looks at a time when technologists' efforts were not necessarily informed by scientific understandings; while the early humans in the cartoon could craft a wheel, they did not yet have the knowledge of physics to understand how the wheel would actually work. In contrast, the cartoon in Figure 2.7 reflects the close contemporary relationship of science and technology. New reproductive technologies are firmly grounded in advances in biology. Still, the cartoonist suggests, the results cannot always be predicted.

Early experiments in transportation

"The Far Side" ©1984 Farworks, Inc./Dist. by Universal Press Syndicate. Reprinted with permission. All rights reserved.

**Figure 2.6**

Gary Brookins, 1984 Richmond-Times Dispatch.

**Figure 2.7**

Several focus questions can guide curriculum development and student understanding of theme 6:

- Historically, what influences did science have on technology?
- Historically, what influences did technology have on science?
- How have the interrelationships between science and technology changed over time?
- In what ways do changes in the organization and structure of science and technology influence their conduct and content?
- Should scientific knowledge be pursued for its own sake apart from technological imperatives?

## The Themes in the Curriculum

In the preceding section, we introduced the six themes independently as conceptual organizers. However, when considering how HNST takes shape in the curriculum, it is difficult to compartmentalize the themes or address the themes discretely in curriculum units or activities. In fact, the richness and effectiveness of the themes may be most fully realized in curriculum units and activities that illustrate and address multiple themes simultaneously. In this section, we offer examples of what an infusion of the HNST themes looks like in a science or social studies curriculum unit.

### *The HNST Themes in a Science Unit*

In a Colorado Springs life science course, the teacher devotes a unit to acid rain, focusing largely on the science of this phenomenon—the chemical reactions that produce acid rain; the chemistry involved in the impact of acid rain on air, water, and buildings; and environmental issues. To conclude the unit, this teacher puts the study of the chemistry and biology of acid rain into the context of society, economy, and contemporary history through several unit focus questions:

- What is the relationship between industry, technology, and acid rain? How has this relationship changed from the 1960s to today?
- What is the relationship among economics, the environment, and legislation?
- How do values of different individuals and interest groups affect concerns about acid rain, acid rain research, and acid rain legislation?

These unit focus questions tie directly to HNST theme 2 (technology as a way of adapting to the world), theme 3 (science and technology as activities that involve human values), theme 4 (social, cultural, and environmental contexts within which they occur influence the conduct and content of science and technology), and theme 5 (science and technology influence the social, cultural, and environmental context within which they occur).

The students in this class then explore the history of U.S. policy regarding acid rain, examining case studies of government policy during different presidential administrations. One student group presents the case of the Reagan administration, which took the position that more research was needed before the United States could impose stringent regulations on emissions from coal burning. This position led the United States into conflict with the Canadian government, which claimed that emissions from U.S. power plants and factories caused damage in Canada. In studying the conflict, students explore the variety of economic, environmental, and technological factors that influenced the Reagan administration decision to postpone restrictions on acid-rain causing emissions. Through the course of this research, students develop a firsthand understanding of themes 3, 4, and 5.

Last year, this life science teacher took the study of acid rain in its societal context a step further by engaging the world geography teacher in an extension project. During a current events session one week, the geography teacher focused on acid rain issues in other regions of the world, asking students to look at the severe problems caused by acid rain and pollution in Eastern Europe. Under communist rule, many European countries pursued policies of heavy industrial production without regard for environmental concerns; they are now paying a severe price. This case study offers both teachers a chance to further enhance students' exploration of themes 3, 4, and 5 by looking at other cultural contexts of science and technology.

### *HNST in a Social Studies Unit*

In a North Carolina middle school, the eighth-grade U.S. history teacher has always conducted a long unit on colonial America and, for several years, has enlivened his course with primary source materials, including farm family diary excerpts he purchased at Sturbridge Village, a living history museum in Massachusetts. Once introduced to the HNST themes, this

teacher infused a technological focus into his existing colonial unit. He now uses a "technological mind walk" activity to introduce students to theme 2 (technology as a way of adapting to the world). After working with the class to reach a working definition of technology, the teacher reads daily excerpts from the farm family diaries, asking students to raise their hands whenever they hear mention of a technology. Students typically mention such things as energy fuels, farm tools, school supplies, household technologies such as butter churns or apparati for making candles or soap or drying food. The teacher's objective is to help students appreciate a broader definition of technology and help them recognize the prevalence of technology in daily life across time periods.

The colonial technology mind walk then serves as a starting point for discussion of the influence of society, culture, and environment on science and technology, and the reciprocal influences of science and technology on society. The teacher asks students such questions as "How did social or economic needs influence which tools were developed during the colonial period? How did available natural resources influence the nature and function of tools and technologies?" Students discuss the prevalence of farm and home technologies, the development of methods for making candles efficiently, churning butter, or creating airtight houses. Students also discuss such questions as how the invention or refinement of various household or farming technologies improved comfort levels, lifestyles, or even changed economic bases—for example, how some farming technologies enabled farmers to manage larger and larger farms.

Our North Carolina teacher expands the technological mindwalk in one of two ways. Through a research project, students create comparable diary accounts of days in the lives of Cherokee Indians of the same time period in North Carolina. In this project, students compare and contrast problems and technological solutions to these problems across cultures, thus developing a deeper understanding of theme 4. By conducting a comparable technology mindwalk for an average day in the students' own lives, the teacher guides students towards a recognition of how newer technologies have replaced historical ones to better meet similar needs and challenges.

The above accounts of science and social studies teachers are just two examples of teachers infusing HNST into their courses. In each case, the teachers extended or enriched existing units in their curricula and, in so doing, addressed several complementary HNST themes. In reflecting on your own curriculum, you might recognize that you already teach several of the HNST themes articulated in this chapter. Or, having reviewed these two brief examples, we hope that you may begin to see windows of opportunity for integrating an HNST component and addressing HNST themes in your classroom. Try the "Your Turn" exercises below to begin thinking about HNST in your own teaching and courses.

## Your Turn:

1. Science Teachers

- **Select a unit within your curriculum in which you already make connections between scientific inquiry or a scientific discovery and its social context. For example, biology and life science teachers might note units they teach on disease; chemistry teachers might identify a unit on atomic theory. Jot down how you teach the unit and what connections you make to social, environmental, or historical contexts. If you can, attach to each of these "connections" one of the six HNST themes.**
- **Next, identify a unit in your current course of study that takes place entirely "in the lab"—perhaps a unit on cell division or physiology. Spend a few minutes thinking about how you could put that unit into an historical, environmental, or societal context. Can you identify a historical or contemporary case study that would enrich the study of a narrow scientific concept or experiment? Try, then, to spin out an extension activity and tag the components of that activity to the HNST themes.**

2. Social Studies Teachers

- **Select a unit within your curriculum in which you already make connections to scientific discovery or technological innovation. U.S. history teachers might readily think of units on the Industrial Revolution, while world history teachers may think of the Renaissance in Europe or science and invention in China. Jot down how you teach the unit and how, specifically, you bring in science and technology. Now, tag these components to the six themes of HNST.**

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- Next, identify a unit within your curriculum in which you do not normally include an explicit focus on science or technology. Some teachers might identify sections of their world cultures curriculum on cultural values. Others might identify a U.S. history unit on the Civil War, in which they focus largely on economics, slavery, and battle campaigns. Take a look at the HNST themes, particularly themes 2, 3, 4, and 5. How might you change or expand your existing unit to focus on these themes?

3. Teachers of Science or Social Studies

- Review your current curriculum and pick a unit in which you already teach about connections between science or technology and history or contemporary society. In what ways could you enrich this unit by team teaching it with a teacher from the other discipline?
- Have a conversation with a teacher from the other discipline to explore the possibilities of a team-taught unit.

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CHAPTER 3

# Getting Started Teaching About the History and Nature of Science and Technology

*Change is a journey, not a blueprint.*
Michael Fullan, 1993

Because the history and nature of science and technology (HNST) encompasses several scholarly fields of study—some of which you may not know a great deal about—getting started teaching about HNST can be a daunting prospect. The idea may be less intimidating if you think about teaching HNST as a path that you can enter at any point; you can remain at your entry point forever or move back and forth along the path as you become more comfortable with this subject matter, your students' needs change, or you are assigned to teach different courses (Figure 3.1).

If you are concerned about knowing the subject matter, you should be reassured to know that resources useful in filling gaps in your knowledge of HNST can be found within your school. These resources are your colleagues in the science department (if you are a social studies teacher) or social studies department (if you are a science teacher). Working cooperatively with teachers

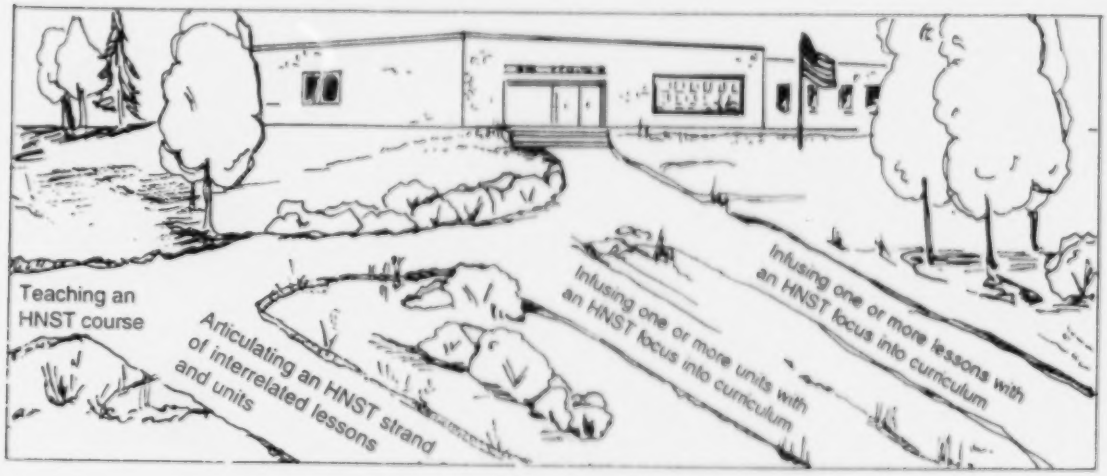
Teaching an HNST course
Articulating an HNST strand of interrelated lessons and units
Infusing one or more units with an HNST focus into curriculum
Infusing one or more lessons with an HNST focus into curriculum

**Figure 3.1: Ways of adding HNST to the curriculum.**

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in another department can have multiple benefits, including a richer learning experience for students. The extent to which you work with another department can vary depending on your particular needs and goals, as well as the needs and goals of the teacher with whom you are working. To return to our path metaphor, each form of cooperation could be seen as a stepping stone useful in crossing certain problem streams blocking the HNST path (Figure 3.2).

In the sections that follow, we describe three options for getting started teaching about the history and nature of science and technology:

1. Infusing discrete HNST lessons or units based on the themes.

2. Developing an HNST strand comprised of interrelated units or lessons.

3. Instituting an HNST course.

In discussing each option, we also provide examples of different ways of working with colleagues in other departments. We then provide some "how-to's" related to lesson and unit planning, as well as examples of interdisciplinary planning and/or teaching to spark your thinking. Finally, we discuss some of the challenges you might face in implementing HNST in your classroom. At the end of the chapter, we provide several practical planning tools for your use.

## Infusing HNST Lessons or Units

Infusion perhaps provides the easiest way of beginning to teach about the history and nature of science and technology. Virtually every social studies and science course offers some opportunities for building specific lessons or units that focus on HNST. Some examples of such opportunities were provided in Chapter 2.

One way to begin identifying infusion opportunities is to create "maps" of your courses, showing the typical units taught and possible HNST topics related to those units. Randy Schnabel, a history and law teacher at Shorewood High School in Seattle, Washington, created such maps for his history courses while attending an HNST summer institute. Part of the map he created for U.S. history is shown in Figure 3.3. A sample from a curriculum map for a biology class is presented in Figure 3.4.

For your convenience, a blank form for use in creating your own curriculum map is provided in the **Planning Tools** section at the end of the chapter. Other techniques for curriculum mapping can also be used. For example, webbing can be effective in this aspect of planning, particularly if your curriculum is issue- or topic-based. Figure 3.5 presents a web an eighth-grade earth science teacher drew as a first step in enriching her unit on space exploration using the HNST themes.

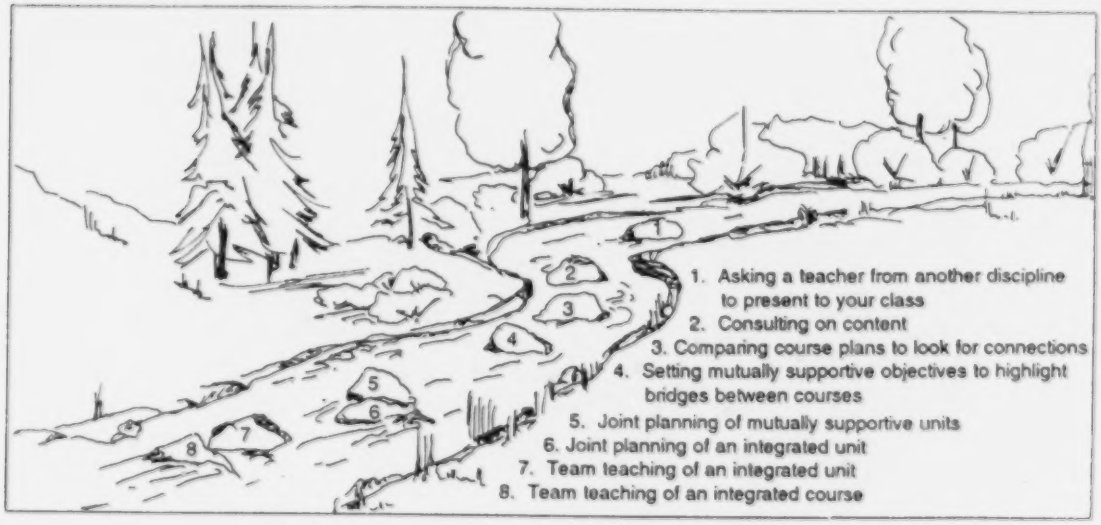
1. Asking a teacher from another discipline to present to your class
2. Consulting on content
3. Comparing course plans to look for connections
4. Setting mutually supportive objectives to highlight bridges between courses
5. Joint planning of mutually supportive units
6. Joint planning of an integrated unit
7. Team teaching of an integrated unit
8. Team teaching of an integrated course

**Figure 3.2: Ways to work with colleagues.**

| Unit | Possible HNST Topics |
|---|---|
| Industrialization and Reform | New technologies and mass production techniques: interchangeability of parts, assembly line, Taylorism (themes 1 and 5: application of scientific methods to social life, belief in value of expertise in managing various enterprises; themes 2 and 4: aspects of American life and culture that may have encouraged the spurt of inventions in this time period; theme 5: impact of new technologies on nature of work and community) |
| | Steel production/oil refining (theme 4: influence of geography—where resources were located—on development of new technologically based industries; government's role in supporting the development of industries) |
| | Transportation/communication systems, particularly railroad, telegraph, and telephone (theme 4: government's influence on the development of the railroad; theme 5: influence of these systems on the economy, culture, and environment of the United States; differential impacts on different groups/regions of the country) |
| | Government regulation: Interstate Commerce Act, Pure Food and Drug Act (theme 3: value conflicts that resulted in the perceived need for regulation—for example, profit versus health; theme 4: influence of government on uses of technology) |
| | Social Darwinism (theme 5: impact of scientific theory on thinking about social interactions) |
| | Changing urban landscape: water, sewer, skyscrapers, electricity (theme 2: development of technologies as a way of adapting to new needs; theme 4: influence of demand for urban housing and availability of new materials on development of new technologies; theme 5: impact of new technologies on urban living) |
| | Beginning of modern computing: expansion of the census in 1890 and use of the Hollerith machine to process results (themes 4 and 5: reciprocal relationships between available technology and potential applications) |
| United States as a World Power | Yellow Journalism (theme 5: new communications and transportation technologies allowed news to be more widely distributed, more quickly, creating new political forces) |
| | Panama Canal: construction, control of disease (theme 4: influence of environmental conditions in Panama on the building of the canal; theme 6: interaction of science with technology, in that research related to yellow fever, its causes, and the conditions necessary for the mosquitos to breed was applied to control the disease among workers) |
| | Military technologies: aircraft, tank, poison gas, submarine, machine gun (theme 5: impact of new technologies on the nature of war; theme 6: application of scientific research to development of such technologies as poison gas) |
| Prosperity: 1920s | Impact of mass production of automobiles (theme 5: impact of automobile on economy, environment, and culture) |
| | Development of new technologies—commercial aviation, radio, synthetic fabrics, motion pictures, phonograph (theme 5: impact of new technologies on culture, economy, environment) |
| | Misconceptions of science: race, IQ, eugenics (theme 1: nature of science; theme 3: values that influenced the conduct of science and the use of scientific information) |

**Figure 3.3: Portions of an HNST infusion plan for U.S. history.**

| Unit | Possible HNST Topics |
|---|---|
| Ecology | Observations, hypotheses, and experimental design (theme 1: nature of science, methods of acquiring scientific knowledge) |
| | Food chains and food webs; early ecologists, such as Ellen Swallow Richards, founder of Wood's Hole Marine Laboratory and first to coin the use of the word *ecology* (theme 4: influence of cultural values on women's role in the scientific community; theme 5: influence of a new science on people's views of the natural world and humans' place in it) |
| | Population growth (theme 3: influence of values on scientific community's response to human population growth; theme 4: influence of cultural values on population control technologies pursued) |
| | Communities and ecosystems; Rachel Carson's *Silent Spring* as a case study in the unintended consequences of such new technologies as pesticides (theme 2), how values influence the way that scientific work is accepted within the scientific community (theme 3) and the larger society (theme 4), and the impact of technology on the environment (theme 5). |
| Evolution | Circumstances and observations leading to the theory; voyage of the Beagle and mapping technologies of the 19th century (theme 1: nature of science; theme 6: interrelationships between science and technology) |
| | Role of natural philosophy in development of the theory of evolution by Darwin and Wallace (theme 1: nature of science) |
| | Possible effects of the theory on society; Social Darwinism; conflicting cultural views of human origins (theme 4: influence of cultural views on acceptance of scientific work; theme 5: influence of scientific advances on thinking in other areas) |
| Genetics | The eugenics movement (theme 3: misuse of scientific information; theme 4: role of cultural values on how scientific information is used) |
| | How DNA structure and function were discovered (theme 1: nature of science; theme 3: how views of scientists' work affected the way in which their ideas on DNA were accepted, role of competition among scientists in fueling research but limiting sharing of results) |
| | Recombinant DNA and genetic engineering; the Human Genome Project (theme 3: role of ethical concerns in shaping the genome project; theme 5: possible environmental and human implications of genetic research; theme 6: relationship between science and technology in pursuing this work) |

**Figure 3.4: Portions of an HNST infusion plan for biology.**

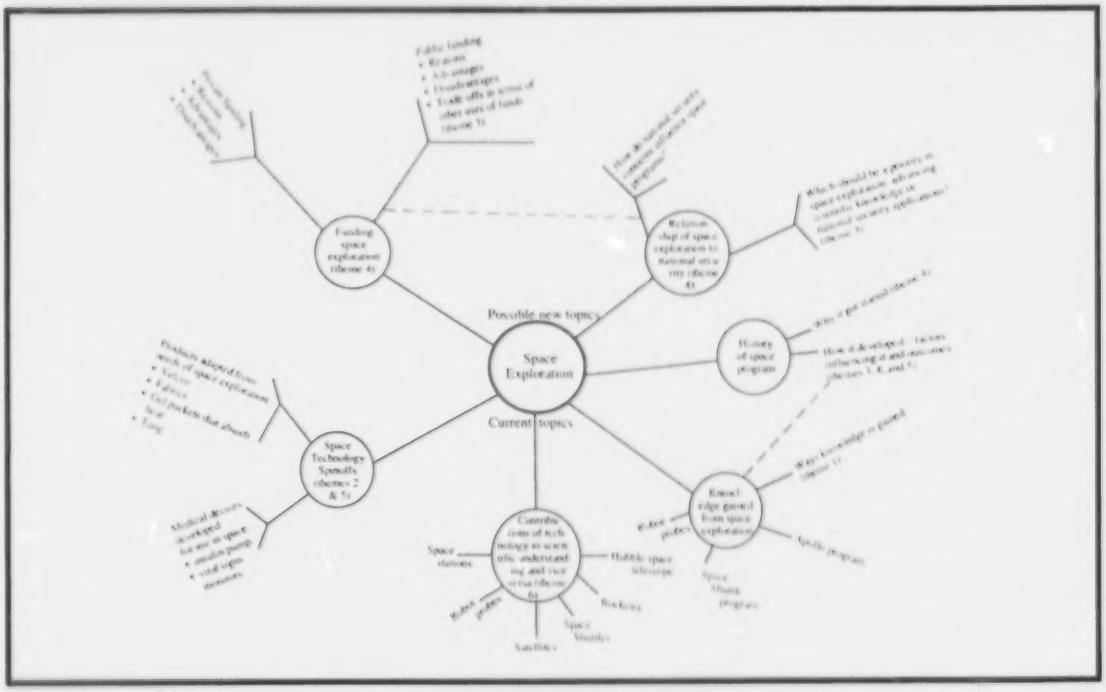
Space Exploration
Possible new topics
Current topics
Funding space exploration (theme 4)
Relationship of space exploration to national security (theme 4)
History of space program
Space Technology Spinoffs (themes 2 & 5)
Contributions of technology to scientific understanding and resources (theme 6)
Knowledge gained from space exploration
Space stations
Hubble space telescope
Robot probes
Satellites
Space Shuttle

**Figure 3.5: Initial web for revising earth science unit on space exploration.**

When you have completed a curriculum map for your course, you will need to decide which of the possible HNST topics you will actually develop into lessons or units. Your decision regarding topics to be developed will be based on a number of factors. Some factors that may be important are:

- The time you can devote to HNST topics.
- The availability of materials, including instructional materials, on the topic.
- The relative importance of the topic, particularly with respect to your overall goals for the unit or course.
- The extent to which the topic can help develop student understanding of one or more of the HNST themes.
- The interest you believe students will have in the topic and their ability to understand the topic.
- The extent to which cooperation with another department might be possible.

If you are interested in working cooperatively with the science or social studies department, your next step might be to show your curriculum map to a science or social studies teacher whose students are drawn from the same class as yours; that is, if you teach 10th-grade world studies, you might consult with a 10th-grade biology teacher. This teacher might simply review your map, looking for ways in which the two of you could work together, or he/she could complete a curriculum map of his/her own; the two of you could then compare maps, looking for possible opportunities for working together. A form useful in summarizing your work together is provided in the **Planning Tools** section of the chapter. This information can guide some decisions about what topics to pursue.

The first item in the list above—the time available—can be a key and highlights the flexibility that the infusion approach offers teachers. Based on the time available and your comfort level, you can choose to do as much or as little HNST as you wish. For example, a team of teachers from Sam Houston Middle School in Garland, Texas, was committed to infusing HNST into

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the curriculum. However, because their school is also committed to interdisciplinary teaching, they recognized that development of HNST materials that fit the local curriculum and were also interdisciplinary would be very time-consuming. Consequently, in their first year of implementing HNST, they concentrated on one unit—an integrated sixth-grade study of the history of flight. The two sixth-grade teachers on the team, Suzy Jungman and Donna Howeth, actually taught the unit, with support from seventh-grade science teacher Angie Kruger and eighth-grade U.S. history teacher Donna Kay Vaughn.

Similarly, Ethel Stone and Bill Martin, a science/social studies team from George Wythe High School in Richmond, Virginia, decided to concentrate their efforts on an interdisciplinary unit on disease. Because their high school is a magnet school for the performing arts, they integrated not only science and history, but also the arts, into the unit.

In contrast, a teacher might choose to teach a number of HNST topics. As an example of how such a teacher might make choices about what topics to cover, let's consider Randy Schnabel's infusion plan for U.S. history. In planning the Industrialization and Reform unit, a teacher using this plan would recognize that he would not have time to treat all of the HNST topics he had listed in any depth. Thus, he decided to choose one topic and spend several days on it and cover the other topics less extensively. His first thought was to focus on the beginning of modern computing because students would find that topic interesting and this example could help develop several themes. On the other hand, the beginning of modern computing is less central to his major goals for the unit than are some of the other topics he listed. The changing urban landscape better represents the "big ideas" of the unit; since his students live in an urban area, the teacher thought the topic could be high interest. He also knew of some materials related to the topic and knew he could link historical issues to current urban issues related to science and technology. Thus, he decided to make his major HNST focus for the unit the changing urban landscape.

After selecting this topic for emphasis, the teacher decided that extensive cooperation with the science teachers at this grade level—most of his history students were taking chemistry—would not be particularly productive. However, he consulted with a physical science teacher to determine how much most students are likely to know about electricity and the mechanical systems required to provide running water in homes. The physical science teacher volunteered to conduct several of Faraday's historical electricity experiments with the history class.

A teacher who knows of instructional materials that can be used to develop a selected topic has a head start. The resource listing in Chapter 5 of this guide can serve as a starting place in looking for materials on topics of interest to you. But what if no relevant materials suitable for your students are available? As most teachers have done numerous times throughout their careers, you take on the role of curriculum developer. We provide a discussion of some useful strategies for developing HNST materials later in the chapter.

One challenge of infusing HNST into a range of social studies and science courses is providing coherence. There may be so many potential hooks in a course that a teacher provides a series of unconnected, fragmented lessons that do not create depth of understanding over time. The need for coherence brings us to our second option, developing an HNST curriculum strand.

## Developing an HNST Strand

To avoid some of the problems of coherence and fragmentation possible with an infusion approach, teachers might think in terms of an articulated HNST curriculum strand. Developing a strand is similar to infusion, in that it involves teaching about HNST within the existing curriculum structure. It is different in that HNST becomes one of the organizing principles for the course or curriculum. The HNST lessons and units taught build upon each other to create a coherent whole.

If you decide to develop an HNST strand, one way to proceed is to choose one or two of the HNST themes as being most germane to a particular course you are teaching. For example, if you are teaching world history, you might select themes 4 and 5, which focus on the reciprocal relationships between science and technology and culture and the environment; a biology teacher, on the other hand, might select themes 1 and 3, which involve the nature of science and the values associated with its practice and use. You would then analyze your current course outline, looking for opportunities to develop student understanding of the selected themes. Some lessons or units could be revised to accommodate the HNST themes, while new lessons or units might be developed to replace older instructional activities that did not address the selected themes. Les-

sons would build on the HNST ideas presented previously.

For example, a biology teacher decided to build an HNST strand based on themes 1 and 3. To focus on theme 1, he decided simply to rework the questions asked throughout the course. Whereas in the past he had emphasized what students know, he decided to begin giving more attention to how students—and scientists—know what they know. He spent considerable time over the summer reviewing all his lesson plans to add this new focus. In addition, he decided to develop one ethical case study for students to consider each quarter. In fact, he decided to begin the year with a case based on the popular novel and film, *Jurassic Park*. This case would not only interest students but would allow him to establish a number of ethical questions that the class could return to throughout the year: Can humans control nature? How should research be funded—by government or by private corporations hoping to profit from their research?

Another option for developing a curriculum strand is to cover all six themes in a course by infusing at least one major learning activity on HNST in each regular unit of the course; each of these learning activities would develop understandings from at least one of the HNST themes. For example, a world history teacher's class is organized into 12 three-week units. She designed a two-day HNST lesson for each unit; the lessons are designed so that each treats at least two themes. Each theme is thus explicitly dealt with three times throughout the year. To illustrate, the teacher covered the relationship between science and technology (theme 6) early in the course when she treated pre-state societies, again when the students examined the development of states, and for the final time when they learned about the integrated technological system of mass production that developed with the industrialized state. The lessons on this theme also developed understandings of the nature of both science and technology (themes 1 and 2).

To supplement an HNST strand, a teacher might plan a major student research project focused on a special HNST topic, such as "Minorities and Technology in U.S. History" or "Gender and Science." Students might conduct the research projects in collaboration with students from another class. An interesting example of such collaborative research is provided by Janice Lane and Gregory Goddard, teachers at St. Louis Park High School in St. Louis Park, Minnesota. Jan, who teaches chemistry, and Greg, who teaches psychology, were committed to working together to implement HNST. However, Jan taught mostly 11th-graders, while Greg's students were generally seniors. Although the content overlaps between their courses were not immediately obvious, they came up with a high-interest topic to which psychology and chemistry could both contribute: the chemistry of romantic attraction. Teams comprised of students from both classes worked together to research specific topics related to this general topic and made presentations to the combined classes.

## Creating an HNST Course

Logically, one might view the creation of elective courses devoted to HNST as the best strategy for implementation. To be sure, a few schools around the country already offer such courses. Often team-taught by science and social studies teachers, such courses present the students who elect to take them with rich and relatively comprehensive learning experiences. These are substantial virtues.

The elective-course approach is not without drawbacks, however. Chief among these is that the HNST themes are important for all students, not just those who might be inclined to take the HNST course. Thus, elective courses do not eliminate the need for and utility of the infusion and HNST strand approaches described above. Another problem related to elective courses is the fact that the curriculum already is crowded in many districts and implementing new electives is increasingly difficult. Furthermore, an elective HNST course might best be team-taught by a science teacher and a social studies teacher. Assignment of two teachers to one course can create staffing problems for school administrators.

HNST courses can take many forms. Each theme could be developed in a separate unit, as shown in Figure 3.6, or they could be integrated into examination of a series of important topics in the history of science and technology, as illustrated in Figure 3.7.

If you set out to develop an HNST course, we recommend that you work in conjunction with at least one other teacher, preferably from the other discipline (science or social studies). Developing the course cooperatively will give you a broader knowledge base on which to draw as well as wider "ownership" for the course.

Before beginning course development, you should think seriously about the students who are most likely to take the course, as well as the teachers most likely to teach it (if other than you). Some questions to guide your thinking are given below (adapted with permission

**Unit 1: The Double Helix: Science as a Way of Explaining the World (Theme 1)**

Watson and Crick's discovery of the structure of DNA will be used as a case study of the nature of science. Students will examine such questions as how and why this research question was formulated, what kinds of observations were used as evidence, and how competing explanations were determined to be less accurate than the double-helix explanation.

**Unit 2: Humans Adapting: Technology in World History (Theme 2)**

In this unit, students will explore the nature of technology by considering the question: Why are there so many different kinds of technological products? They will examine the problems various technologies have been designed to solve and look for explanations as to why technological solutions have varied from time to time and place to place. Hands-on activities will allow students to explore the process of developing technologies.

**Unit 3: The Manhattan Project: Science, Technology, and Human Values (Theme 3)**

Through this unit on the Manhattan Project, students will examine how values and science interact at various levels. For example, they will consider the views of scientists who chose to participate in the project, as well as those who did not, focusing particularly on Edward Teller, Robert Oppenheimer, and Lise Meitner. They will also consider the role of ethics and values in making decisions about the uses of technology, in this instance focusing on Truman's decision to use the atomic bomb.

**Unit 4: The Case of Galileo: Society's Influence on Science (Theme 4)**

The suppression of Galileo's work by the Church will be compared with other cases in which public sentiment restricted the work of scientists. Contemporary cases to be included in the unit include research linking violent behavior with genetic causes and cancellation of the supercollider project.

**Unit 5: The Industrial Revolution: Science and Technology Influence Society (Theme 5)**

This unit will focus on how the Industrial Revolution changed society, giving particular emphasis to the changing workplace and to urbanization. Both intended and unintended effects of various technologies will be studied, with students conducting a research project on the impact of new household technologies.

**Unit 6: Interrelationships Between Science and Technology: Three Case Studies (Theme 6)**

In this unit, students will examine the changing relationships of science and technology by examining their relationships in three historical periods. First they will examine the two enterprises in the pre-state period, then during the development of the nation state, and finally in the modern industrialized state.

**Figure 3.6: HNST course outline with each unit focused on a different theme.**

**Unit 1: What Is History and Why Should We Study the History of Science and Technology?**

Through activities in which students explore the role of science and technology in their own lives and family history, this unit will provide a rationale for studying HNST. Students will also compare and contrast the work of historians, scientists, and technologists.

**Unit 2: Medieval Technology and the Medieval World-View**

In this unit, students will compare and contrast medieval technology in China and Europe, focusing on the different uses and reactions to technology in these two different cultures.

**Unit 3: The Scientific Revolution**

In this unit, students will study the Scientific Revolution, examining how the development of what we call modern science changed the ways in which we evaluated knowledge and saw human's relationship to nature. The new mechanical view of the universe and its multiple effects on society and culture will be examined.

**Unit 4: The Industrial Revolution**

This unit will examine the impact of the Industrial Revolution, focusing particularly on the changing workplace and urbanization. Differential impacts in different places will be studied, as will factors that affected whether an area became industrialized.

**Unit 5: The Scientific Age: Conceptual Upheavals**

In this unit, students will be exposed to recent advances in science that have challenged the Newtonian view of the universe. Particular attention will be given to how the nature of science itself may be changing as a result of advances, particularly in physics.

**Unit 6: The Scientific Age: Big Science**

This unit will focus on how the contemporary practice of science in large institutions has changed the nature of science and what kinds of science are done. Current relationships between science and technology will also be studied.

*Adapted from Carroll 1987.

**Figure 3.7: HNST course outline with themes integrated.**

from Glatthorn 1987). The student questions will help you understand the constraints imposed by the characteristics of students who will probably take the course. The teacher questions will help you decide how detailed your planning should be and how much staff development you will need.

THE STUDENTS: Consider the students likely to take the course and find out...

1. What is the ability range?

2. What levels of cognitive development are represented?

3. What is known about their academic achievement? What prior classes or content do they bring to the course?

4. What are their predominant values and attitudes relative to course content?

THE TEACHERS: Consider the teachers likely to teach the course and find out...

1. How interested are they in teaching the course?

2. How much do they know about the content to be covered?

3. How skilled are they as teachers?

4. Will they teach cooperatively with a science/social studies teacher? Do they have experience with such cooperative teaching?

Gathering course outlines (even for university courses) will be useful, as will collecting curriculum standards documents.

If the HNST course was adopted as part of a district curriculum, goals for the course have probably been written. If no such goals have been developed, however, the next step in course planning is to delineate the purposes of the course. Such national curriculum documents as *Benchmarks for Science Literacy* may be useful in establishing goals.

Once goals have been established, you can begin blocking in the units that will comprise the course. A useful first step is brainstorming a number of units that could be part of the course (the sample course outlines you collect will be useful in this process, as will your own academic training and interests). In deciding about the number, focus, and sequence of the units, you may find it helpful to think through the following questions (adapted with permission from Glatthorn 1987):

1. Which units will help students acomplish the goals of the course? Which units will appeal to student interest? Which units will be manageable within the time constraints? Which units will be the most exciting to teach? Try to identify one general outcome for each unit you have listed. Use the outcomes to give each unit a title.

2. How many of these units will you actually have time for? Consider the goals of the course, the length and schedule of the course, and the interest span of the learners.

3. What is an appropriate length for each unit and how should the units be sequenced? By reflecting about the unit objective and the nature of the learners, make a tentative decision about the length of each unit. Then determine the optimal sequence by answering these questions:

- Which unit will best capture student attention?
- How does the flow of units match the school calendar?
- Is some developmental progression desirable—does one unit build upon another?
- Which unit would make a strong ending, bringing several threads together?

Once you have the units blocked out, you should develop a unit-planning guide—a general planning outline that can guide the detailed development. Figure 3.8 shows a completed guide for a unit on science and public policy. A general guide is provided in the **Planning Tools** section of the chapter.

## Developing HNST Materials

As you begin developing an HNST lesson or unit on a particular topic, gather the related materials you are aware of; although you may not have found any curriculum materials on the topic, you will likely be able to locate readings that could be adapted for your students, primary source materials, related experiments, and the like. Having these at hand will be very useful in developing your teaching plan.

Next, think carefully about your purpose in teaching this lesson or unit. What knowledge do you want students to gain? What skills or processes will you introduce or reinforce? What attitudes or values will be targeted? What HNST themes will this lesson or unit help students understand? With your objectives or outcomes clearly in mind, designing instructional activities and preparing student materials will be easier and more productive.

Title of Unit: **Science, Public Policy, and the Public Interest**

**General Unit Objective:** Students will be able to provide well-reasoned positions, supported with historical and contemporary cases, on the following questions:

1. Under what conditions, if any, would it be in the public interest to prohibit or limit certain lines of scientific investigation, to keep investigations secret, or to prevent a person from disseminating a scientific theory?

2. Under what conditions, if any, might a scientist's obligations to his/her profession conflict with obligations to his/her country or to humankind? How should these dilemmas be resolved?

3. What is the citizen's obligation to understand science? What kinds of public policy questions should citizens delegate to scientists and experts?

**Length of Unit:** 10 class periods

**Important Concepts:** nature of science, the role of citizens and experts in developing public policy, public interest, value conflicts, ethical decision making

**Important Skills/Processes:** Students will develop discussion skills, including setting an agenda, summarizing, active listening, making clear transitions, stipulating resolutions to disputed factual claims, and being open to new ideas; they will also learn skills for analyzing ethical, fact-explanation, and definitional issues, particularly the use of analogies.

**Important Values/Attitudes:** Students will examine values related to the practice of science and consider how conflicts between these values and other values can be resolved by the individual scientist. They will also focus on attitudes of citizens toward data presented by scientists and other experts and how those attitudes affect decision making.

**Suggested Learning Activities:**

1. Small-group discussion on central questions; development of tentative answers.

2. Small-group decision-making exercise related to cases in which someone tried to suppress scientific information; possible cases are the suppression of Galileo's work by the Church, Leo Szilard's efforts to prevent publication of experimental results from studies of nuclear fission, efforts by fundamentalist Christian groups to stop the teaching of evolution, and recent controversy over research linking genetics and violent behavior.

3. Reports from small groups to large group, followed by large-group discussion of critical question 1.

4. Voting with your feet activity related to use of Nazi data.

5. Reading and discussion of Robert Oppenheimer's security hearing.

6. Writing assignment: Is a scientist's primary obligation to science, to him/herself, to his/her country, or to humankind?

7. Viewing of *Lorenzo's Oil* and discussion of how people can make decisions about technical issues.

8. Case study analysis involving public policy decisions in which scientists have presented conflicting evidence; possible issues include the safety of hazardous waste sites following government clean-up efforts; the feasibility of the Strategic Defense Initiative; and the likelihood that global warming poses a serious threat to the environment. Students will try to develop criteria for evaluating scientific data presented to the public as a basis for decision-making.

**Evaluation Plan**: Students will return to the tentative answers to the organizing questions developed at the beginning of the unit and revise their answers on the basis of the understandings gained in the unit.

**Figure 3.8: Unit plan.**

Brainstorm several activities you might use in the lesson or unit. Consider a variety of learning styles and a mix of strategies. Begin arranging the activities in a sequence that will maximize interest and learning; Chapter 4 presents an instructional model that may be useful in this planning process, while Appendix A provides background on some teaching strategies you may want to consider. Also keep the following criteria for quality learning experiences in mind (adapted with permission from Glatthorn 1987):

1. The learning experience provides an opportunity to construct meaning, to make sense of students' experience, to integrate knowledge.

2. The learning experience seems likely to involve all students in the active processing of experiences.

3. The learning experience is diverse. It requires the use of many learning styles, modalities, and talents.

4. The learning experience is ethical. It does not use deception by students or teachers and in no way diminishes the dignity of participants.

5. The learning experience is challenging. It requires the students to go beyond what they already know to process information, to synthesize it, apply it, and create new forms.

6. The learning experience is appropriate for the context (the classroom or the community) and the participants (the teachers and the students).

7. The learning experience is relevant. It relates to and contributes to the unit objective.

You should also think about how you will evaluate student learning. What essay questions could you ask to evaluate student learning? What performance-based tasks would demonstrate student achievement of the objectives? How would you encourage students to reflect on and assess their own learning?

Whenever you are developing curriculum, we recommend that you write up your plans as though they were going to be published. Doing so not only enhances the possibilities that someone else could actually use your lessons, but also ensures that you have not forgotten any important steps in developing your plans. To assist you in the process, the **Planning Tools** section presents a format for professional instructional plans. In addition, Chapter 4 contains several model lessons developed using a similar format.

## Interdisciplinary Planning and Teaching

Throughout the preceding discussion, we have provided several examples of how teachers in science and social studies can work together to implement HNST in the curriculum. You should not, however, let these examples limit your thinking about how you might work with teachers from other disciplines. Creative teachers have developed many ways of working together, sometimes in the face of substantial obstacles.

A team of teachers from New Trier High School in Winnetka, Illinois, provide an interesting case study. This highly regarded high school is organized in a traditional department-based manner. The three teachers who decided to attend an HNST institute represented the science and social studies departments and had never worked together on a project before. In addition, they teach a range of classes, with few overlapping students: David Goodspeed teaches biology, Betsy Parker teaches chemistry and physics, and Don Rogan teaches A.P. American history and coordinates the district's educational technology program.

The three teachers wanted to work in an interdisciplinary fashion, but the challenges at first seemed almost insurmountable. With time to work as a group, however, they were able to develop a creative plan that builds on the unique history of the Chicago area. Students in all three teachers' classes were introduced to the Colombian Exposition of 1893 and challenged to prepare exhibits for a school exposition. The exhibits focused on a scientific advance or a technological development and were designed to convey the history and significance of the advance or development. The exhibits were created by small groups of students working together. On the day of the exposition, students also had responsibility for examining and evaluating other exhibits. Students' evaluations will be used to select a limited number of exhibits to be saved for a large exposition on the school's 100th anniversary. Other teachers were invited to a workshop that focused on how their students could benefit from the exposition, which was open to everyone in the school and community. Following the first exposition, additional teachers were brought into the project, providing a broader base of student participation for the second year.

Jose Luis Pacanowski and Gilberto Quintana, teachers in a bilingual program at John Jay High School in Brooklyn, New York, developed an interdisciplinary HNST unit centered around field experiences. Students learned about technologies developed around the turn of the century, as well as about the impact of those technologies on New York City; they then visited the sites to examine the technologies and impacts firsthand.

Another creative example is provided by teachers at Kelly Walsh High School in Casper, Wyoming. For many years, science teacher Elizabeth Horsch and social studies teacher Roxie Dever offered an integrated course centered around a case study chosen by students and the teacher. Whatever the topic of the case study—land use, natural resources, energy, policy-making, personal energy consumption—students designed and conducted a major study on the topic or issue. Whenever possible, students worked with scientists and engineers in the community to improve their study design. Through this process, students learned a great deal not only about the topic of their case study, but also about the nature of science, the work of practicing scientists, and the impact of science and technology on society and the environment.

Interdisciplinary work need not be confined to science and social studies. Mathematics, language arts, computer, music, or art teachers can also be involved in HNST lessons or units. Literature provides a different perspective on many issues related to the history and nature of science and technology. For example, a physics teacher and a language arts teacher could cooperate in teaching a unit using the 1993 novel *Einstein's Dreams*, by Alan Lightman; a history teacher and a language arts teacher could examine the impact of television on culture using the recent *The Day the Televisions Stopped*, by S.B. Sutton. A discussion with a language arts teacher could undoubtedly reveal numerous such connections with the course that you teach.

Similarly, art reflects changes in technology through the technologies used by artists and through the subjects of their art. Many artists in various media have commented on the impact of technology. In addition, artists are often among the first to reflect how world views change as science offers new evidence about the nature of the world. The book *Art and Physics: Experiments in Space, Time, and Light*, by Leonard Shlain, examines relationships between science, technology, and art and might therefore be a useful starting point for teachers who want to explore connections with art. Again, a discussion with an art teacher in your school could reveal fruitful connections with your courses.

Music, too, can provide another perspective on the relationships among culture, science, and technology. Two useful resources in planning how music might be integrated into HNST lessons or units are *The Ballad of America: The History of the United States in Song and Story*, by John Anthony Scott, and *The Green Book: Songs Classified by Subject*, by Jeffrey Green. The history of musical instruments themselves provides yet another avenue for exploring links between culture and technology. As with connections in literature and art, we recommend consulting the music teacher to plan how best to link music and the study of HNST.

While working with another teacher requires additional effort, the payoffs can be significant, for both you and your students. We encourage you to be creative in exploring the ways that you can work with colleagues in other departments to enrich your teaching about the history and nature of science and technology.

## Challenges in Implementing HNST

As you implement HNST, you are likely to face challenges, some easily overcome, some faced with more difficulty. Below we discuss the challenges we have found to be most common, along with some strategies for working on these issues.

Your own hesitancy about tackling new subject matter in which you may not feel your academic training is strong may be one obstacle. One way of addressing this issue is to start with only a small change in your curriculum and work up to a more ambitious revision. Another strategy is to look for training opportunities in this area. You may have noted that many of the teachers we talked about in this chapter had attended a summer institute on the history and nature of science and technology. This institute was supported by the National Science Foundation, which sponsors a variety of institutes that may be relevant. Local colleges may also offer courses in this subject area. The **Interesting Readings for Teachers** section of Chapter 5 could provide a starting point for a personal reading list to enhance your own knowledge related to the history and nature of science and technology.

Our own experience and that of teachers we have worked with indicates that curriculum materials on the history and nature of science and technology are not abundant. Chapter 5 does provide listings of a number of such materials, but you may well be unable to find

materials on a particular topic in which you are interested. It was for this reason that we addressed the issue of developing materials in this chapter. The lessons in Chapter 4 should also be helpful in providing models for how to develop your own lessons. Of course, in developing lessons related to ethical issues in science and technology, the newspaper, newsmagazines, and television news can provide a rich source of material.

Your students may also present a challenge—not because they are not interested in the content, but because they may have misconceptions that will need to be addressed. For example, many students may think of technology as applied science. They will need to be introduced to the craft basis of technology in history, as well as the many technologies that have been developed before the science underlying their operation was fully understood. While much contemporary technology does represent the application of scientific understandings, science and technology have and continue to be separate enterprises. Similarly, many students may see technological development as a matter of "progress." These students will need to be given opportunities to explore the unintended and differential consequences of technologies. In teaching about HNST, you will need to be alert to these misconceptions and flexible in planning ways of addressing them.

Another challenge you may face is lack of interest among colleagues in your own department or in another department with which you would like to work. Steve Welch, a middle school teacher from Vermont, found this to be true of his colleagues, simply because they had so many other demands on their instructional and planning time. Steve found that by conducting an HNST unit that was highly engaging to students and by infiltrating HNST content into enrichment time, an aspect of the curriculum that was less highly structured than the core classes, he was able to generate interest among his colleagues over the course of the school year. By demonstrating the success that could be achieved when teaching about the history and nature of science and technology, Steve allowed his colleagues to see cooperation with him on this effort as a win-win situation. Making the benefits of working with you on HNST clear is a key to winning support from others.

If you decide to seek a substantial change in curriculum to accommodate HNST, you may need administrative support to buy materials, attend training, or get scheduling flexibility for team teaching. In gaining administrative support, you will find it helpful to link what you are trying to do with the history and nature of science and technology to other priorities in your school or district. Perhaps, for example, your district is emphasizing interdisciplinary instruction; HNST is a natural vehicle for linking science and social studies. Linking HNST to your district's standards or outcomes statements can also be a powerful tool.

In working with administrators, it is also helpful to have a group of like-minded colleagues committed to a well-articulated plan. Before approaching an administrator for support, you would do well to seek some collegial involvement and to think through the curricular changes that you hope to make.

Our purpose in mentioning these challenges is not to intimidate you, although we recognize that the list is somewhat daunting. We began this chapter with the idea of short-range planning to make incremental changes in your teaching. We hope that your success in involving students with the important "big ideas" embodied in HNST will lead you to adopt more ambitious long-range goals. With these challenges in mind as you begin your planning, you will be able to anticipate possible obstacles and prepare for them well in advance.

## Your Turn:

**Review the options for teaching about the history and nature of science and technology covered in this chapter. Which seems most feasible for you at this time? Outline a process you will follow in planning to implement this option for the next school year.**

## Planning Tools

The final section of this chapter presents tools that numerous teachers have used successfully in planning to teach about HNST for the first time. These tools include a format for infusion planning (i.e., curriculum mapping), a matrix for interdisciplinary planning, a unit planning guide, and a suggested format for instructional plans. We encourage you to adapt these tools to meet your own particular needs.

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## References

Carroll, P. Thomas, "History of Science and Technology," in Terry S. Reynolds (ed.), *The Machine in the University: Sample Course Syllabi for the History of Technology and Technology Studies* (Bethlehem, PA: Lehigh University, 1987).

Crichton, Michael, *Jurassic Park* (New York: Alfred A. Knopf, 1990).

Glatthorn, Allan A., *Curriculum Renewal* (Alexandria, VA: Association for Supervision and Curriculum Development, 1987), Chapter 6.

Green, Jeffrey, *The Green Book: Songs Classified by Subject*, 3rd rev. ed. (Nashville, TN: Professional Desk Reference, 1989).

Lightman, Alan, *Einstein's Dreams* (New York: Pantheon Books, 1993).

Sutton, S.B., *The Day the Televisions Stopped* (New York: Harcourt Brace, 1992).

*Teaching About the History and Nature of Science and Technology: Curriculum Framework* (Colorado Springs, CO: BSCS, and Boulder, CO: SSEC, 1992).

Scott, John Anthony, *The Ballad of America: The History of the United States in Song and Story* (Carbondale, IL: Southern Illinois University Press, 1983).

Shlain, Leonard, *Art and Physics: Experiments in Space, Time, and Light* (New York: Morrow, 1991).

# SUGGESTED FORMAT FOR INFUSION PLANNING

Fill in the name of your course below. Then list the major units taught in the course. For each unit, fill in HNST topics or issues that you will develop. You may find it helpful to work with other teachers at the same grade level.

Course:_____

| Units (Be Specific) | HNST Infusion Ideas |
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# MATRIX FOR INTERDISCIPLINARY PLANNING

Fill in the names of the course offerings at each grade level in the first column below. Then use your infusion planning sheets to indicate what HNST topics will be developed in the science and social studies courses. In the final column, put some suggestions for how the science and social studies teachers might work together in presenting HNST topics.

| **Course Offerings** | **HNST Topics to Be Covered in Science** | **HNST Topics to Be Covered in Social Studies** | **Opportunities to Work Together** |
|---|---|---|---|
| Grade Level:___<br>Science Course:<br>Social Studies Course: | | | |

# UNIT PLANNING GUIDE

**Title of Unit:** Give the unit a descriptive title. Although a clever title may seem more engaging, it will not give other teachers a clear sense of what the unit is about.

**General Unit Objective:** Describe what students will understand and be able to do at the end of the unit. Focus on the "big ideas" of the unit.

**Length of Unit:** Give the number of class sessions that will be devoted to the unit, specifying the length of the class session so that the unit length can be adjusted if class periods are changed.

**Important Concepts:** List important concepts to be developed; you may find it useful to list the concepts by disciplines so that science and social studies can more easily make connections to their disciplines.

**Important Skills/Processes:** List the skills or science processes to be developed in the unit. Again, it may be useful to categorize the skills/processes (e.g., critical thinking, writing, investigating/testing/experimenting).

**Important Values/Attitudes:** List the values or attitudes that will be addressed in the unit. Again, it may be useful to categorize the values (e.g., attitudes about scientists and their work, values of democratic citizenship).

**Suggested Learning Activities:** List the major learning activities that will make up the unit. These learning activities will be explicated in greater detail in your daily lesson plans.

**Evaluation Plan:** Describe how student learning will be assessed.

# SUGGESTED FORMAT FOR INSTRUCTIONAL PLANS

## Title:

## Introduction:

Briefly describe the focus of the lesson, as well as the major teaching activities. List questions concerning HNST that the lesson addresses.

## Learning Outcomes or Objectives and Indicators:

Using the method employed in your district, state what students will know, be able to do, and value upon completion of the unit. Also state how you will determine whether the outcomes have been achieved.

**Teaching Time Required:** Give the number of class periods required to complete the lesson.

**Level:** Specify the appropriate grade level(s).

**Disciplines/Courses:** Indicate the discipline or courses in which the lesson could be used.

**Materials and Equipment:** Specify the materials and equipment that will be necessary to use the lesson.

**Preparation:** If any special preparation is required (other than gathering materials), give directions for that preparation.

## Instructional Activities:

**Engage.** Develop an activity that engages the students in the learning task. The activity should (1) make connections between past and present learning experiences and (2) anticipate activities and organize students' thinking toward the learning outcomes.

**Explore.** Develop an activity or series of activities that provide students with a common base of experience within which current concepts, processes, and skills are identified and developed. The activities in this phase should be concrete and active.

**Explain.** Develop an activity or series of activities that focuses students' attention on a particular aspect of their engagement and exploration experiences, providing opportunities to demonstrate conceptual understanding. You may introduce concepts, processes, or skills at this point, as well as clarify misconceptions.

**Elaborate.** Design an activity or series of activities that helps students extend their understanding by gathering new information, applying concepts to new cases, and the like.

**Evaluate.** Describe how you will assess student understanding and provide opportunities for students to reflect on and evaluate their own progress.

CHAPTER 4

# The Themes in Action: Sample Lessons on the History and Nature of Science and Technology

## Introduction to an Instructional Model

Everyone who teaches has some type of model that informs his or her teaching strategies. For most people, this model has evolved gradually and is not necessarily a conscious effort to teach in a certain manner. Our goal in this chapter is to provide information about one possible instructional model along with examples of lessons that were developed using this model and the six HNST themes. Current research indicates that all learners build ideas and understanding based on their experiences. The cognitive psychologists working in this area have developed a theory called the contructivist theory of learning. They believe that each learner puts together (or constructs) his or her understanding of the world. You can apply this theory to anything one learns about, from fixing cars to understanding plate tectonics to learning about learning.

**Constructivism is a theory about learning that says all learners build their understanding of the world based on their experiences.**

Consider the following scenarios and then respond to the questions in the box titled "Your Turn."

### *Scenario 1*

"Okay, everyone close your eyes for a moment and imagine being on a battlefield in New Jersey in January. It is dawn and it's 20 degrees inside your tent. The wind is strong and damp, and the British troops are just over the ridge. You can't see them but you can feel them out there. General Washington says if you can make it through this battle in one piece, you should be able to pick up some provisions at Trenton. All you know is it would be nice to have boots without holes for some part of the winter and you wouldn't mind eating a warm meal tomorrow when you turn 17.

Now, use what you imagined and what we have studied about the American Revolution to write a letter back home as though you were this young soldier. Imagine that you made it through the impending battle at Princeton, but sustained a flesh wound in your left shoulder. In your letter record the following types of information in the first person (as though you are this soldier):

- Your feelings about being in the war and away from home.
- Any information about the strategies of the battle that may interest your family, which includes a retired soldier.
- A description of the geography of the area.

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- The type of treatment you got for your wound and how it is doing.

Please be prepared to read your letters aloud on Thursday. As you develop the text of the letter use as many resources as you can, including your notes, reference materials about the battle of Princeton, the topography and other maps in your textbook, the lab work you have just completed in biology class, and any relevant personal experiences you've had, such as a visit to a battlefield. After everyone has had a chance to read his or her letter aloud in small groups, Jose will show slides from his family's trip to Fort Ticonderoga to provide a view of one of the places from the same war."

### *Scenario 2*

"Class, please take out your notebooks and something to write with. Today I am going to explain the process of photosynthesis to you. Your homework for tonight is to read Chapter 11, 'Photosynthesis: An Amazing Transformation of Energy,' in your textbook. Answer the questions at the end of the chapter before class begins tomorrow. Your completed homework is your ticket into lab tomorrow. The lab activity will confirm the information in the book by showing you the difference in the starch content in the leaves of a plant I am keeping in the closet and one I have on a nearby window sill.

Okay, now begin your notes with the big heading 'Photosynthesis.' Your next two headings will be 'The Light Reaction' and 'The Dark Reaction.' Obviously, you can tell by the major headings for today's lecture that there are two key parts to the process of photosynthesis..."

## Your Turn:

1. **Compare and contrast the two scenarios above. What are the strengths of each? What are the weaknesses? Respond to these questions from both a teacher's perspective and a student's perspective.**
2. **Compare your assumptions about how students learn to the assumptions that guide each of the teachers in the scenarios.**

The scenarios above represent two extremes of the range of possibilities in the classroom. They are intentionally extreme so that you can get an obvious sense of the difference between a constructivist classroom and a non-constructivist classroom. After you read the brief background below, decide which scenario represents a constructivist approach.

Constructivism, as a set of ideas about how people learn, has been in existence for more than 20 years, principally through the work of researchers such as Ernst von Glaserfeld and Les Steffe. Since the late 1980s, references to constructivism have occurred frequently and consistently in the education literature. Constructivism represents a significant shift in the view of the learner from one who must be taught the correct explanation for phenomena to someone who interacts with the world and brings those experiences to the classroom (or any other setting). From a constructivist perspective, learning is a social process that the teacher works to facilitate by helping students make sense of their experiences and further their understanding of the world through the use of all the senses. For a more complete description of these ideas, please refer to *Handbook of Research on Science Teaching and Learning*, *In Search of Understanding: The Case for Constructivist Classrooms*, or *Strategic Teaching and Learning: Cognitive Instruction in the Content Areas*.

If you embraced the constructivist theory of learning fully in the classroom, you would let each learner put together ideas individually and add more experiences and information as the learner is ready. For the teacher who has 30 students in each of five sections, this is not a reasonable proposition. To make the idea of constructivism more approachable, people have begun creating instructional models that increase the opportunities for learners to construct their own understandings of phenomena. In 1985 the BSCS, through the work of Rodger Bybee, developed an instructional model organized around five words beginning with the letter "E." Consequently, this instructional model is known as the 5Es:

- Engage
- Explore
- Explain
- Elaborate
- Evaluate

This model extends the original learning cycle developed at the Lawrence Hall of Science by Robert Karplus and used in the SCIS (Science Curriculum Improvement Study) elementary science program.

When BSCS and SSEC began working on the HNST *Curriculum Framework*, we included the 5E instruc-



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tional model as a suggested set of strategies to organize one's instruction about HNST. Consequently, the model has been incorporated into our work in these materials also. As you read through the sample lessons at the end of the chapter, keep in mind that the 5Es are only one way to organize your instruction. You can adapt the lessons to reflect other models of instruction.

The 5E instructional model organizes instruction around the basic idea that all learners have a set of experiences that influence their ability to learn more or different ideas and concepts that comprise your curriculum. According to this instructional model, you begin by organizing the learners. You first **engage** them in a concept by asking a question or doing a discrepant event. In the first scenario, the students experienced mental engagement in the lesson if they participated in the guided imagery. This imagery allows the students to gain a perspective on a particular part of the American Revolutionary War. The second scenario does not offer as clear an example of engagement as the first. It is possible that listening to the overview of the day mentally prepared and excited the students in the concepts of the lesson.

After they are engaged, the students participate in one or more activities that help them **explore** the concept. This exploration provides the class with a common set of experiences that you can use to identify misconceptions and develop a dialogue about the concept. In scenario 1 the learners explored a number of ideas by beginning their assignment to write a letter. The students in scenario 2 did not explore much of their prior experience with plants and photosynthesis. Instead they went directly to a reading assignment that provided someone else's explanation of photosynthesis.

The 5E model includes an opportunity for explanation, though not as typified in scenario 2. In the **explain** phase, you clarify the concept and define the relevant vocabulary. At this time the students also explain their understanding of the concept, which again helps you identify the level of understanding in the classroom. If the majority of students do not have a clear understanding of the concept, then it is reasonable to return to the explore phase. The letter-writing activity in scenario 1 provides an opportunity for the students to explain their understanding of several topics: geography, feelings about war, battle strategies, and the biology of wound treatment in a historical setting. This scenario does not include a description of the teacher-directed part of the explain phase. Scenario 2 focuses primarily on a teacher-directed explanation of photosynthesis. Although the 5E model allows for the use of this strategy, its use in isolation does not allow the learner to construct his or her own understanding. The most that will happen is that the students will be able to regurgitate the teacher's or the book's explanation of a particular topic or concept.

If most students have a grasp of the key concept you are teaching, then it is appropriate to move on to the **elaborate** phase. In this phase the students build on their understanding of the concept by applying it to new situations. Depending on what the teacher in scenario 1 does with the letter reading and Jose's slide show, students may have an opportunity to elaborate their understanding. Similarly, in scenario 2 there may be an opportunity for elaboration if the students conduct the lab activity themselves instead of confirming the teacher's results.

To close the instructional model, the students complete an activity that helps you and them **evaluate** their understanding of the concept. Neither scenario provides an example of an evaluate activity or strategy. Tables 4.1 and 4.2 summarize teacher and student behaviors that are consistent or inconsistent with each stage of the 5Es. Figure 4.1 shows how the stages of the model are reflected in one of the lessons in this chapter.

## Overview of Sample HNST Lessons

To provide some ideas for how you might implement the six HNST themes and the instructional model, we have included 10 sample lessons at the end of the chapter. The lessons focus on widely varying subject matter and use diverse teaching strategies, illustrating that the constructivist instructional model can be applied in many courses and by teachers with differing teaching styles.

Table 4.3 summarizes the lessons to help you identify those that would be appropriate for your courses.

## References

Brooks, Jacqueline Grennon, and Martin G. Brooks, *In Search of Understanding: The Case for Constructivist Classrooms* (Alexandria, VA: Association for Supervision and Curriculum Development, 1993).

Gabel, Dorothy L., *Handbook of Research on Science Teaching and Learning* (New York: Macmillan, 1994).

Jones, Beau Fly, and others, *Strategic Teaching and Learning: Cognitive Instruction in the Content Areas* (Alexandria, VA: Association for Supervision and Curriculum Development, 1987).

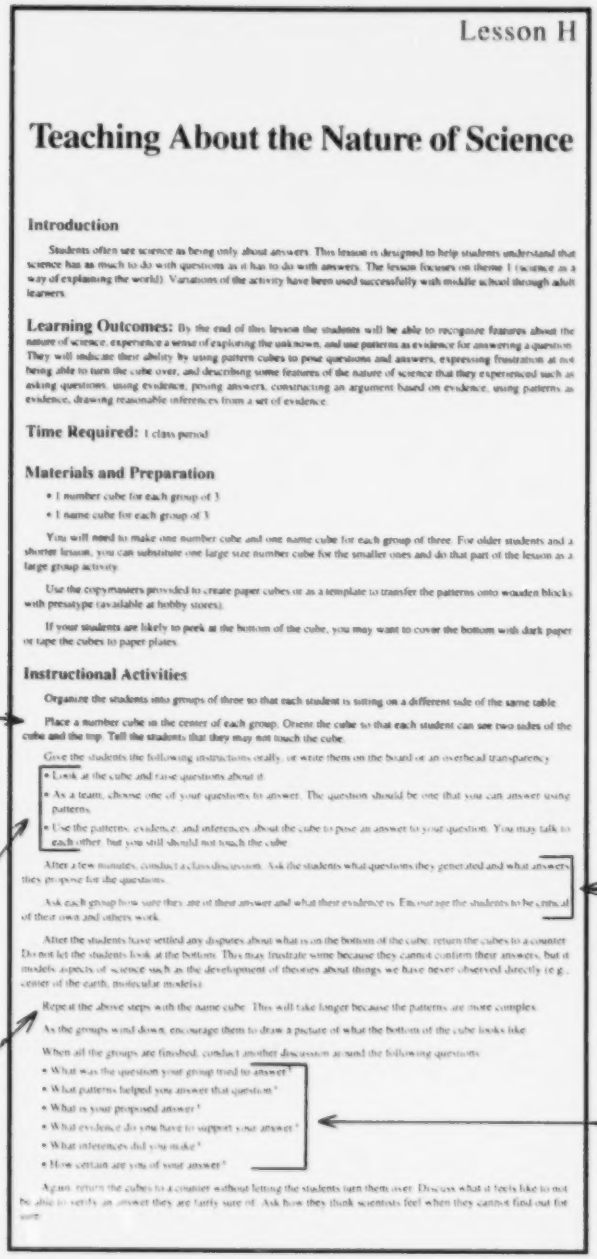
*Teaching About the History and Nature of Science and Technology: A Curriculum Framework* (Colorado Springs, CO: BSCS, and Boulder, CO: SSEC, 1992).

# Table 4.1
# TEACHER ACTIONS IN THE 5E MODEL

| Stage of the Instructional Model | What the Teacher Does | |
|---|---|---|
| | That Is Consistent with This Model | That Is Inconsistent with This Model |
| Engage | • Creates interest<br>• Generates curiosity<br>• Raises questions<br>• Elicits responses that uncover what the students know about a concept | • Explains concepts<br>• Provides definitions and answers<br>• States conclusions<br>• Provides closure<br>• Lectures |
| Explore | • Encourages the students to work together without direct instruction<br>• Observes and listens as students interact<br>• Asks probing questions to redirect the students' investigations<br>• Provides time for the students to puzzle through problems<br>• Acts as a consultant for students | • Provides answers<br>• Tells how to work through the problem<br>• Provides closure<br>• Tells the students that they are wrong<br>• Gives information that solves the problem<br>• Leads the students step-by-step |
| Explain | • Encourages students to explain concepts in their own words<br>• Asks for justification<br>• Formally provides definitions and explanations<br>• Uses students' previous experiences as basis for explaining concepts | • Accepts explanations that have no justification<br>• Does not solicit student explanations<br>• Introduces unrelated concepts or skills |
| Elaborate | • Expects the students to use formal definitions and explanations<br>• Encourages the students to apply or extend the concepts and skills<br>• Suggests alternative explanations<br>• Refers the students to existing data and evidence and asks: What do you already know? Why do you think...? | • Provides definitive answers<br>• Tells the students that they are wrong<br>• Lectures<br>• Leads students step-by-step<br>• Explains how to work through problem |
| Evaluate | • Observes the students as they apply new concepts and skills<br>• Assesses students' knowledge and/or skills<br>• Looks for evidence that the students' understanding has grown<br>• Allows students to assess their own learning and group-process skills<br>• Asks open-ended questions such as: Why do you think...? What evidence do you have? How would you explain x? | • Tests only vocabulary words, terms, and isolated facts<br>• Introduces new ideas or concepts<br>• Creates ambiguity<br>• Promotes open-ended discussion unrelated to the concept or skill |

# Table 4.2
# STUDENT ACTIONS IN THE 5E MODEL

| Stage of the Instructional Model | What the Student Does | |
|---|---|---|
| | That Is Consistent with This Model | That Is Inconsistent with This Model |
| Engage | • Asks questions such as: What do I already know about this? What can I find out about this?<br>• Shows interest in the topic | • Asks for the "right" answer<br>• Insists on answers or explanations<br>• Seeks one solution |
| Explore | • Thinks freely, but within the limits of the activity<br>• Forms and tests new predictions and hypotheses<br>• Tries alternatives and discusses them with others<br>• Records observations and ideas<br>• Suspends judgment | • Lets others do the thinking and exploring<br>• Little or no interaction with others<br>• "Plays around" indiscriminately with no focus<br>• Stops with one solution |
| Explain | • Explains possible solutions to others<br>• Listens critically to others' explanations<br>• Questions others' explanations<br>• Listens to and tries to comprehend explanations the teacher offers<br>• Refers to previous activities<br>• Uses recorded observations in explanations | • Proposes explanations from "thin air"<br>• Brings up irrelevant examples<br>• Accepts explanations without justification<br>• Does not attend to other plausible explanations |
| Elaborate | • Applies new definitions, explanations, and skills in new situations<br>• Uses previous information to ask questions, propose solutions, make decisions, design experiments<br>• Draws reasonable conclusions from evidence<br>• Records observations and explanations<br>• Checks for understanding among peers | •"Plays around" with no goal in mind<br>• Ignores previous information or evidence<br>• Draws conclusions from "thin air"<br>• Uses in discussion only those labels that the teacher provided |
| Evaluate | • Answers questions by using observations, evidence, and previously accepted explanations<br>• Demonstrates an understanding of the concept<br>• Evaluates his or her own progress<br>• Asks related questions that encourage future investigations | • Draws conclusions without using evidence or previously accepted explanations<br>• Offers only yes-or-no answers and memorized definitions or explanations as answers<br>• Introduces new, irrelevant topics |



Lesson H

# Teaching About the Nature of Science

**Introduction**

Students often see science as being only about answers. This lesson is designed to help students understand that science has as much to do with questions as it has to do with answers. The lesson focuses on theme 1 (science as a way of explaining the world). Variations of the activity have been used successfully with middle school through adult learners.

**Learning Outcomes:** By the end of this lesson the students will be able to recognize features about the nature of science, experience a sense of exploring the unknown, and use patterns as evidence for answering a question. They will indicate their ability by using pattern cubes to pose questions and answers, expressing frustration at not being able to turn the cube over, and describing some features of the nature of science that they experienced such as asking questions, using evidence, posing answers, constructing an argument based on evidence, using patterns as evidence, drawing reasonable inferences from a set of evidence.

**Time Required:** 1 class period

**Materials and Preparation**

- 1 number cube for each group of 3
- 1 name cube for each group of 3

You will need to make one number cube and one name cube for each group of three. For older students and a shorter lesson, you can substitute one large size number cube for the smaller ones and do that part of the lesson as a large group activity.

Use the copymasters provided to create paper cubes or as a template to transfer the patterns onto wooden blocks with presstype (available at hobby stores).

If your students are likely to peek at the bottom of the cube, you may want to cover the bottom with dark paper or tape the cubes to paper plates.

**Instructional Activities**

Organize the students into groups of three so that each student is sitting on a different side of the same table.

Place a number cube in the center of each group. Orient the cube so that each student can see two sides of the cube and the top. Tell the students that they may not touch the cube.

Give the students the following instructions orally, or write them on the board or an overhead transparency.

- Look at the cube and raise questions about it.
- As a team, choose one of your questions to answer. The question should be one that you can answer using patterns.
- Use the patterns, evidence, and inferences about the cube to pose an answer to your question. You may talk to each other, but you still should not touch the cube.

After a few minutes, conduct a class discussion. Ask the students what questions they generated and what answers they propose for the questions.

Ask each group how sure they are of their answer and what their evidence is. Encourage the students to be critical of their own and others work.

After the students have settled any disputes about what is on the bottom of the cube, return the cubes to a counter. Do not let the students look at the bottom. This may frustrate some because they cannot confirm their answers, but it models aspects of science such as the development of theories about things we have never observed directly (e.g., center of the earth, molecular models).

Repeat the above steps with the name cube. This will take longer because the patterns are more complex.

As the groups wind down, encourage them to draw a picture of what the bottom of the cube looks like.

When all the groups are finished, conduct another discussion around the following questions:

- What was the question your group tried to answer?
- What patterns helped you answer that question?
- What is your proposed answer?
- What evidence do you have to support your answer?
- What inferences did you make?
- How certain are you of your answer?

Again, return the cubes to a counter without letting the students turn them over. Discuss what it feels like to not be able to verify an answer they are fairly sure of. Ask how they think scientists feel when they cannot find out for sure.

The cube itself will intrigue the students and serve as an engage.

These instructions provide the guidance for an exploration.

In this activity, repeating the process with a more complex cube gives students an opportunity to elaborate their understanding.

Discussions are useful for helping students construct their understanding because they must articulate their ideas and listen to others. This is one type of explanation.

The questions provide an opportunity for both teachers and students to evaluate their understanding of the lesson.

**Figure 4.1. Lesson plan annotated to show the stages in the 5E instructional model.**

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# Table 4.3
# SUMMARY OF SAMPLE LESSONS

| Title | Middle or High School | Content Area | Theme |
|---|---|---|---|
| A. Bad Blood: The Tuskegee Study of Untreated Syphilis (pp. 47-58) | HS | U.S. History, Biology | 3, 4 |
| B. Energy Conservation and Culture (pp. 59-64) | MS | World Geography or History, Physical Science | 2, 4 |
| C. The Impact of the Automobile on Society (pp. 65-80) | HS | U.S. History | 5 |
| D. Paper Clip Lifters (pp. 81-87) | MS | Physical Science, Earth Science | 2 |
| E. Rachel Carson's Work: A Historical View of Population Dynamics (pp. 89-95) | either | Biology, Geography | 5 |
| F. Renewable Energy and the American Age of Wood (pp. 97-110) | HS | U.S. History | 2, 3, 4, 5, 6 |
| G. Taking Another Look at Television (pp. 111-118) | MS | Physical Science, Current Events | 2, 4, 5 |
| H. Teaching About the Nature of Science (pp. 119-122) | either | Integrated Science | 1 |
| I. Technology Learning Stations (pp. 123-125) | either | History, Geography, Physical Science | 2, 4 |
| J. Thinking About Bioethics (pp. 127-133) | HS | Biology, Civics, Government | 3 |

Lesson A

# Bad Blood: The Tuskegee Study of Untreated Syphilis

## Introduction

The Tuskegee Study of Untreated Syphilis, conducted by the U.S. Public Health Service on African-American men from 1932-1972, is the longest nontherapeutic experiment on human beings in medical history. Students learn about syphilis, its diagnosis and treatment through history, and about the Tuskegee Study. In this lesson, students examine HNST theme 3 (science and technology are activities that involve human values) and theme 4 (the social, cultural, and environmental contexts within which they occur influence the conduct and content of science and technology). Students consider the following questions concerning the history and nature of science and technology:

- How do society's values affect the questions scientists ask and the ways in which they seek answers to those questions?
- What are the relationships among race, class, and the conduct and content of scientific research?

***Note that this activity requires some student knowledge of U.S. race relations in the early 20th century. Students should be familiar with the pattern of social segregation and unequal access to quality education and the legal system experienced by African-Americans in the post-Reconstruction South.***

**Learning Outcomes:** Students take part in a voting-with-your feet activity related to the influence of social conditions on scientific and medical research. They then read about the historical development of the discovery and treatment of syphilis. They work in small groups to learn and present information based on roles related to the Tuskegee Study of Untreated Syphilis and analyze the study to determine how culture and human values influence medical research.

**Time Required:** 2-3 class periods

## Materials and Preparation:

- Handouts A-1, A-2, A-3, and A-4; make overhead transparency of Handout A-3
- Instruction cards

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Based on information from *Bad Blood: The Tuskegee Syphilis Experiment—A Tragedy of Race and Medicine* (New York: The Free Press, 1981).

## Intructional Activities

Tell students they will be spending the next several days examining a medical study conducted in the United States from 1932-1972. Learning about the study will help them decide whether and how society and culture influence the conduct and content of science.

Draw a long line on the chalkboard with the following positions at either end:

---

Scientific and medical research is often influenced by prevailing social conditions and attitudes.

Scientific and medical research is free from influence by prevailing social conditions and attitudes.

Open the discussion by presenting the two sides of the issue. Then tell students they are going to express their opinions on the issue by voting with their feet. Ask students who agree with the statement at one end of the continuum to come to the front of the room and stand by the statement; those who agree with the other statement should stand at the other end of the continuum. Those who have positions between the two extremes should position themselves along the line to show their relative disagreement/ agreement with the two statements.

Ask for a volunteer near one end of the line to explain his/her position; allow time for someone with the opposing view to respond. Allow students time to respond to each other and change their positions along the continuum. When the comments appear to be winding down, allow students to return to their seats.

Ask students to record their thinking about the issue in two or three sentences; direct them to save this writing piece in a notebook so they can reexamine their position later. Tell students that over the next several class periods they will learn about a medical experiment conducted on African-American men suffering from syphilis. Encourage students to reexamine their position on the continuum as they learn about this experiment.

Ask students what they know about syphilis: how it is spread, how it affects the human body, and whether a cure for the disease exists. Record student ideas on the board.

Distribute Handout A-1 and ask students to read the information about the history of the disease and its treatment. After students have completed the reading, have them amend and add any new facts to the information on the board.

Distribute Handout A-2 as a reading assignment or present the information as a short lecture. Use the questions for discussion to check student understanding of the information and to discuss any ethical dilemmas they recognize in the study.

Arrange the class into groups of four. Distribute the Instruction Cards so that each group member has a different reading assignment. Each student will read about a person who participated in the Tuskegee Study. Direct students to read about and be able to explain their assigned participant's role in the study.

Distribute Handout A-3; ask students in each group to present to their group members what they learned about a Tuskegee Study participant. As each group member reports, students should record information in their retrieval charts.

When groups have finished sharing, ask students to report to the class information about each participant in the Tuskegee Study. Record on the chalkboard or overhead transparency of Handout A-3.

Tell students that their groups will now spend 10 minutes discussing the following real-life scenario:

> In 1969 a panel of medical experts met to decide whether the Tuskegee Study should continue. The experts, all of whom were white Southern doctors, discussed the pros and cons of continuing the study, then reached a decision.

Direct students to talk about the panel discussion with their group members. What might the panelists' arguments for continuing the study have been? Arguments for ending the study? Ask students to come up with possible arguments on both sides of the issue and prepare to present them to the class. Students may post their arguments, or you may ask representatives from each group to present their arguments on both sides of the issue.

Tell students that a panel of medical experts did meet in 1969 to determine whether the study should continue.

Distribute Handout A-4, or present the information in a brief lecture. Ask students to compare their discussion of the panelists' arguments to the actual decision reached by the panel. Ask students if they can identify social and cultural influences on the doctors involved in the study that affected the conduct of the study. Record their ideas on the board. Ask students how these societal/cultural influences interrelated with the values of the individual doctors.

Return to the continuum from the introductory portion of the lesson. Ask students to vote with their feet on the same issue. Ask students along the continuum to describe their position on the issue now. Did evidence from the Tuskegee Study change their position? If so, what evidence was crucial to their new understanding? If not, why not?

Ask students to refer to the statements they wrote in their notebook when this lesson began. Ask them to write their current position on the impact of society and culture on science, including how knowledge of the Tuskegee Study may have influenced their opinion.

## Going Further

A 1993 NOVA video program, *The Deadly Deception*, presents a fascinating look at the Tuskegee Study of Untreated Syphilis through the voices and stories of people involved in the study. The video also introduces a play based on the Tuskegee Study, titled "Miss Evers' Boys." Students will find the NOVA program riveting and chilling after their own study of this medical experiment. The video program is available from Films for the Humanities, 800/257-5126.

To further explore societal, cultural, and human values and their impact on the conduct and content of science, students may do research on medical experiments performed in Nazi concentration camps during World War II, on U.S. medical experiments testing the impact of plutonium on human subjects in the 1940s, on U.S. heart disease studies conducted on men only, or on a host of other historical or recent studies. Students may present information in oral or written reports, role plays, or other forms.

Inform students that because of past problems with medical research on women and minorities, the National Institutes of Health now have guidelines for inclusion of women and minorities in such research. Ask students to consider what kinds of provisions should be included in such guidelines. Some of the key provisions in the guidelines are that:

- Women and minorities must be included in medical research so that gaps in our knowledge of health problems affecting women and minorities do not persist.
- Women and minorities cannot be excluded from medical studies because of cost factors.
- Researchers must actively recruit members of these groups to participate in their studies.
- If preliminary research shows gender or racial/ethnic differences in the effectiveness of treatment, final trials must include sufficient numbers of women and minorities to allow these differences to be analyzed.

# SYPHILIS AND ITS TREATMENT

During the 1880s, the Austrian physician Sigmund Freud began treating patients for mental as well as physical illnesses. Some of his patients suffered from what was then called *dementia paralytica*, a disease in which physical paralysis occurred, followed by insanity. Doctors at the time did not know what caused the disease. No effective treatment existed, and patients who developed the disease generally died in insane asylums.

Doctors did suspect a connection between sexual activity and the onset of *dementia paralytica* later in life. Because of the suspected connection with sexual activity, the disease was given the name syphilis, after a young shepherd in a 16th-century love poem.

In 1905, two German scientists identified the microbe that causes syphilis, the bacterium *Treponema pallidum*. This spiral-shaped bacterium could be cultured from blood samples of infected patients. Doctors learned that the disease is transmitted when the bacteria are passed from one person to another through skin contact with an infected sore or chancre or through sexual contact. It may also be passed from mother to fetus, through the placenta.

Once doctors had a means of detecting who was infected with *Treponema pallidum*, they could recognize three stages of the disease, all caused by the same bacterium. The first stage, primary syphilis, occurs within three weeks of infection, when a hard, painful sore called a chancre appears at the site of infection. The chancre disappears within four weeks. Some people infected with the bacteria never develop the chancre. Secondary syphilis occurs two to four months later and is signaled by a skin rash, painful bones and joints, fever, indigestion, and headaches. This second stage of the disease is often followed by a period of latency during which symptoms may disappear altogether. If the disease enters the third or tertiary stage, it can cause rubbery tumors to develop on skin, bones, internal organs, and the central nervous system. Softening of the brain, or neurosyphilis, causes the paralysis and insanity observed by Freud in the 1880s.

By 1910, a scientist named Paul Erlich announced the discovery of a medical treatment that stopped the bacteria from multiplying, preventing the later stages of syphilis. The compound, sold under the name Salvarsan, contained arsenic, which was highly toxic and could cause slow poisoning of the patient. Treatment with Salvarsan required 20 to 40 doses, injected into muscle over the course of a year, to arrest the infection. The treatment was risky and painful.

In the 1940s, penicillin became widely available as a cure for bacterial disease. It proved effective in killing the syphilis bacteria without the risks associated with Salvarsan; because of the widespread use of penicillin as a treatment for syphilis, the rate of syphilis infection quickly dropped to an estimated 20 cases per 100,000 people in the United States.

## References:

Benenson, A.S. (ed.), *Control of Communicable Disesases in Man*, 12th ed. (Washington, DC: The American Public Health Association, 1975).

BSCS, *Biological Science: An Ecological Approach*, 7th ed. (Dubuque, IA: Kendall/Hunt Publishing Company, 1992).

Committee on Infectious Diseases and American Adademy of Pediatrics, *Report of the Committee on Infectious Diseases*, 21st ed. (Elk Grove Village, IL: American Academy of Pediatrics, 1988).

Raven, P.H., and G.B. Johnson, *Understanding Biology*, 2nd ed. (St. Louis, MO: Mosby Year Book, 1991).

Shorter, E., *The Health Century* (New York: Doubleday, 1987).

# THE TUSKEGEE STUDY OF UNTREATED SYPHILIS

In 1972, an Associated Press reporter broke a shocking story: for 40 years, the U.S. Public Health Service (USPHS) had been conducting a study of the effects of untreated syphilis on African-American men in Macon County, Alabama. Over the years of the Tuskegee Study of Untreated Syphilis, named for the educational institution that housed the study in its early years, a variety of tests and medical examinations were performed on 400 men with tertiary syphilis. Investigators tracking the disease in these men wanted to learn about serious complications that developed in the final stage of the disease.

In the study's early years, government doctors provided limited treatment to men enrolled in the study. At the time, penicillin was not yet available as a cure for bacterial infections; treatment with an arsenic compound called Salvarsan was offered in a sporadic way. None of the men in the Tuskegee study who received Salvarsan treatment received enough of the compound to cure the disease.

When penicillin became available as a treatment for syphilis, it was not offered to the Tuskegee patients. In fact, men enrolled in the study were carefully monitored by the project's head nurse, Eunice Rivers, and by local doctors, to ensure that they received no treatment for syphilis.

Over the course of the study, many of the men died of syphilis. Those who didn't die from the disease and lived to describe their experience said that they never understood what the study was about, but they believed they were being treated for "bad blood."

## Questions for Discussion:

1. Based on your knowledge of tertiary syphilis, describe the symptoms men enrolled in the Tuskegee Study might have been suffering during the years of the study.
2. Why do you think the study was conducted on African-American men?
3. How might information obtained from the Tuskegee Study have benefitted society? List any possible benefits you can think of.
4. Can you think of any ethical questions that might have arisen over the course of the study? If so, what are they?
5. How do you think the government doctors conducting the study might have dealt with such ethical questions?

# RETRIEVAL CHART

As group members describe the participants in the Tuskegee Study, fill in any information you learn about them.

| Roles | Education and Background | Attitude toward PHS Doctors | Attitude toward African-Americans | Role in the Study |
|---|---|---|---|---|
| PHS Doctor | | | | |
| Nurse Rivers | | | | |
| African-American Man in Study | | | | |
| Macon County Doctor | | | | |

# HISTORICAL AFTERMATH

The Blue Ribbon Panel that met in 1969 decided the Tuskegee Study should continue and that the men enrolled in the study should not receive penicillin to treat their syphilis. Most of the panel members believed that the study had provided important new understandings of the disease and would continue to do so. Some panel members argued that treating the men with penicillin now could cause health problems; only one doctor on the panel argued that the men should be treated. For him, the study raised ethical questions. Unless the men were treated, he warned, the study was sure to be criticized. The same doctor also was disturbed by other panel members' apparent inability to see the men enrolled in the study as human beings. To the majority of the panel, he believed, the men were merely scientific subjects.

Following the panel's decision, the Public Health Service entered the 1970s determined to continue the study until the last subject had died. None of the surviving men in the study received treatment for syphilis through the remaining years of the study.

When the Associated Press broke the story about the Tuskegee Study in 1972, Dr. Merlin Duval, assistant secretary for health and science affairs at the U.S. Department of Health, Education, and Welfare, told reporters he was "shocked and horrified" by the Tuskegee Study. He launched a full investigation into the study, promising a special effort to determine "why the study was permitted to continue past the time when penicillin became the effective drug of choice against the disease."

Duvall appointed a nine-member citizens' panel, five of whom were African-American, to investigate the Tuskegee Study. Its first report, issued in late April 1973, was highly critical of the entire study. The panel determined that the experiment was "ethically unjustified in 1932," because it failed to obtain the informed consent of participants in a study of a disease with a known risk to human life. Penicillin, the report stated, should have been made available to the participants as of 1953 when it became widely available. Finally, the panel argued that existing policy related to the use of human subjects in experiments did not provide adequate protection.

Senator Edward Kennedy held hearings on human experimentation in early 1973. Two survivors of the Tuskegee Study, Charles Pollard and Lester Scott, provided the most poignant testimony, unfolding a 40-year saga of lies and deceit, of uneducated men betrayed by government doctors. In the wake of the hearings, the federal government issued completely revamped regulations on human experimentation. For the survivors of the Tuskegee Study, the new regulations came too late. The federal government did promise comprehensive medical care to survivors for the rest of their lives; their families subsequently received medical treatment as well.

In July 1973, Fred Gray, a nationally-known civil rights attorney, filed suit in U.S. District Court for $3 million in damages for each living participant and for heirs of the deceased. In December 1974 the U.S. government settled the case out-of-court: all survivors received a $37,500 cash payment; heirs of deceased participants received $15,000 each.

No PHS doctors who had been directly involved in the study ever admitted any personal wrongdoing; none apologized for their role in the study. Years after the experiment had ended, Nurse Rivers refused to believe it had harmed the men, but she did admit that withholding penicillin from the men in the study may have been an error.

More than 20 years after the Tuskegee study ended, questions surrounding the study still had an impact on American life. Dr. Henry Foster, nominated by President Bill Clinton to be U.S. Surgeon General, denied having knowledge of the study prior to 1972. Some of his Senate detractors claimed they had evidence linking Foster to a meeting deciding the fate of the study in the late 1960s. In the spring of 1995, Foster's nomination, which ultimately failed, hung on this and other controversial issues.

# PUBLIC HEALTH SERVICE DOCTOR

*Read the following information about a Public Health Service doctor's involvement in the Tuskegee Study. Be ready to describe his role in the study, his attitudes towards the men being studied, reasons for conducting the study as he did, and his beliefs about the importance of the study to the medical community.*

* * * * *

Dr. Johnson is a Public Health Service (PHS) doctor, employed by the U.S. government. He grew up in the South and shared many of the attitudes of Southerners in the 1930s towards African-Americans. He followed a long line of Southern physicians who, beginning in the 19th century, sought to prove the physical and mental inferiority of African-Americans in order to justify slavery and, after the Civil War, social segregation. In the early 1930s, Dr. Johnson became interested in determining whether African-Americans are affected differently than whites by syphilis. His hunch was that African-Americans, whom he believed to lack virtue, were more prone to contract this sexually-transmitted disease than were whites and were likely to suffer different manifestations of the disease.

In an initial study in 1933 to determine the number of cases of syphilis among African-Americans in Macon County, Alabama, Dr. Johnson found a high rate of syphilis in the African-American male population there. Realizing that he had a "ready-made opportunity" to study the effect of syphilis on African-Americans, Johnson pushed for an extension of the study. In his new study, he included African-American men who were at least 25 years old and who had had syphilis for at least five years. Johnson's new study did not include treatment for the disease; in fact, he met with local Macon County doctors to seek their cooperation in not treating the men for syphilis. Johnson was interested in determining the process of the disease in African-American men: how it affects them differently from whites. The new study was open-ended: PHS doctors would follow the progress of the disease in the men until they died.

In the 1940s, when penicillin emerged as a painless and non-hazardous cure for syphilis, Johnson and other PHS doctors did not provide it to the men enrolled in the study. After all, they were interested in studying *untreated* syphilis in these men.

Over the years of the study, as the men died of the disease, PHS doctors were able to perform autopsies and determine how the disease had affected their cardiovascular and central nervous systems, as well as their vital organs. These doctors published numerous articles in medical journals detailing their findings.

When asked about the study, Dr. Johnson was quoted as saying: "We didn't tell the men what was being done. We told them we wanted to test them. They were not told, so far as I know, what they were being treated for or what they were not being treated for." The men "thought they were being treated for rheumatism or bad stomachs....We didn't tell them we were looking for syphilis. I don't think they would have known what that was."

# NURSE RIVERS

*Read the following information about Nurse Rivers' involvement in the Tuskegee Study. Be ready to describe her background, role in the study, attitudes toward the men being studied and toward the government doctors for whom she worked.*

* * * * *

Nurse Rivers is an African-American woman, born in Macon County, Alabama. She graduated from Tuskegee Institute in 1922 with a degree in nursing. Following graduation, she worked as a public health nurse in the county. In both her schooling and training as a nurse, Rivers learned to respect the doctor and follow his orders. It was her job, she believed, to serve the doctor and not ask questions.

In 1931 Rivers lost her job, but was recommended for a new position with the Public Health Service (PHS). In this new job, she would assist PHS doctors studying syphilis in African-American males in the county. Rivers eagerly accepted the job. It would be exciting to do important work with government doctors, whom she held in high esteem.

In the early part of the study, Nurse Rivers' role was to drive around the county, picking up men at their homes and bringing them to the hospital for testing. She drove a government-issued car, with a government emblem on it; she got to know the men, and they enjoyed their rides to the hospital with her. Rivers also assisted the doctors in their medical examinations of the men.

As the study continued beyond 1933, Rivers' role became increasingly important to the PHS. While the PHS rotated a different doctor each year to perform the "annual roundups"—blood and other tests on the men—it was her job to keep the men interested in the study. Rivers was able to do this, in part, by making the men believe they were receiving valuable medical care. It was also her job to prevent the men from seeking treatment for syphilis from local doctors. Many times over the years she intercepted men who sought treatment for the disease, telling the doctors, "he's under study and not to be treated."

Another aspect of Rivers' job was to ensure that, when the men died, they would be autopsied. She frequently had to convince widows and other family members to allow doctors to perform autopsies. Beginning in 1935, Rivers was able to offer burial stipends to families in exchange for permission to perform autopsies. She became close to the men and their families over the years of the study and attended funeral services for all those who died. The men liked and trusted her, and called their group a "social club and burial society" and "Miss Rivers' Lodge."

Nurse Rivers' role was vital to the continuation of the study. Over its 40 years, she was the only staff person who remained constant. She served as the glue between the rural African-American men enrolled in the study and the white government doctors.

# MACON COUNTY AFRICAN-AMERICAN MAN ENROLLED IN THE STUDY

*Read the following information about the involvement of an African-American man in the Tuskegee Study. Be ready to describe his background, attitudes toward the government doctors, understanding of the study, and general health.*

* * * * *

Charles Woods was born in Macon County, Alabama. He worked as a sharecropper for a white landowner. Woods and his family and nearly everyone he knows is very poor. He had never received medical treatment in his life prior to the Tuskegee Study; he simply didn't have the money to pay for medical care. Most people Woods knows can barely get by; he and his family suffer from chronic malnutrition and are frequently sick with one diet-related disease or another. The schools in Macon County are inadequately funded; most people Woods knows can neither read nor write.

In the early 1930s, life was especially hard for Woods. The onset of the Great Depression meant jobs were even more difficult to come by. When he heard about an opportunity to enroll in a medical study at the Tuskegee Institute, Woods saw it as a chance to receive regular medical check-ups and free treatment. After a blood test, the "government doctor" found that he had "bad blood" and that he would be tested periodically for this condition. The doctor gave Woods some pink pills, which made him feel better.

Besides the check-ups, Woods also received a hot meal on the day of the check-up and a ride in the station wagon with the government emblem driven by Nurse Rivers. His participation in the study gave him a sense of increased status in his community. Woods' participation ensured that his family would be able to afford a funeral service for him upon his death without having to go into debt.

Woods believed that the government doctors who treated him for "bad blood" over the years had his best interests in mind, even though the examinations he underwent were often painful. Despite the doctors' care, Woods and others he knew in the study were frequently ill. Some went blind; others became insane. Throughout the years of the study, Woods was never really told what it was all about, but he trusted the doctors to know what was best for him.

# MACON COUNTY DOCTORS

*Read the following information about a Macon County doctor's involvement in the Tuskegee Study. Be ready to describe his role in the study, his attitudes towards the men being studied, and his beliefs about the significance of the study to the medical community.*

* * * * *

Dr. Shively is a member of the Macon County, Alabama, medical society. Shively is a white male, raised in the South, and generally in agreement with other white Southerners in his racial attitudes. Namely, Shively believes in the physical and mental inferiority of African-Americans. Still, he provides medical treatment for African-Americans in the county who can afford to pay for his services.

In 1933, Dr. Shively was approached by a Public Health Service doctor about an important syphilis study being conducted in his county. The PHS doctor sought his cooperation in this study: he asked Shively to pledge that he would not treat any of the men enrolled in the study for syphilis. The PHS doctor gave Shively a list of all the men enrolled in the study and asked him to help maintain the death watch over the men: if one of the men on the list was very ill or appeared to be near death, Shively was to alert Nurse Rivers. The nurse would then be able to take the man to the medical facility where he would die and be autopsied.

Flattered by the invitation to participate in a major national scientific study, Shively agreed to cooperate with the government doctors. Neither he nor any of his fellow Macon County doctors questioned whether the study was ethically or scientifically sound.

Lesson B

# Energy Conservation and Culture

## Introduction

Energy resources are important to all industrialized nations. Japan's highly industrialized economy is almost completely dependent on imported energy resources—oil bought from Middle Eastern countries and Indonesia and coal bought from Australia, the United States, and Canada. As a result, Japan spends a great deal every year buying coal and oil, and the price of energy resources in Japan is high. In their homes, the Japanese people have found numerous ways to save on energy costs. They have, for example, developed a number of heating devices that use much less energy than central heating systems.

In this lesson, students brainstorm ways they would keep warm. They then explore one Japanese device, leading to a comparison of U.S. and Japanese approaches to energy use. The activity concludes with students designing an energy-efficient heating device.

The lesson, which focuses on themes 2 and 4, addresses the following questions concerning the history and nature of science and technology:

- What influence do geography and culture have on the problems that technologists pursue?
- What influence do geography and culture have on the way in which technological solutions are used?

**Learning Outcomes:** Students brainstorm ways of keeping warm and examine one Japanese heating device that is not used in this country. Through this process, they begin to see that there are diverse solutions to the same problem and that culture affects the solutions adopted in a particular society. They describe several energy-efficient heating devices and distinguish between devices that use renewable and nonrenewable energy sources. They also design an energy-efficient heating device.

**Time Required:** 2 class periods

## Materials and Preparation:

- Copies of Handouts B-1 and B-2
- Drawing materials

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Adapted from Lynn S. Parisi, *The World: Lands and Peoples* (Waterbury, CT: Graphic Learning, A Division of Abrams & Company Publishers, Inc., 1992).

## Instructional Activities

Pose the following question to students: It is winter. You are doing your homework and feel cold. What do you do? Encourage students to brainstorm as many possible answers to this question as they can. Post their answers on the chalkboard.

Ask students to speculate on whether people in different cultures would do something not on students' list.

Divide the class into small groups and give each group a copy of Handout B-1. Tell the groups they will have five minutes to decide how they think the heating device shown in the picture works.

At the end of five minutes, have each group share its explanation.

Distribute Handout B-2 and read it with the students. As students read, ask them to underline all the heating methods mentioned in the reading.

Next, ask students to classify each method identified as one using a nonrenewable énergy resource, one using a renewable energy resource, or one using no energy in order to work (although making it would have required energy). Also have students classify the heating methods as to whether they heat a person, a room, or a whole house.

Return to students' brainstormed list of ways they would keep warm. Have students classify all the methods as using nonrenewable energy resources, renewable energy resources, or no energy resources. Also have them indicate what is heated by each method—a person, room, or house.

Ask students to compare the lists for the United States and Japan. What differences and similarities do they see? (They are likely to observe that while both countries use many nonrenewable energy resources, U.S. methods of keeping warm use more energy than Japanese methods.) How might they account for differences? (Japan has few energy resources and the price of fuel is therefore very high in Japan; Japanese people are more accustomed to a lifestyle that involves some sacrifice; other answers.) Help students reach the understanding that while two cultures may be at the same level of technological development, they may use technologies differently because of geographic, economic, or cultural factors.

Working in pairs, have students design a warming or cooling device that uses little or no energy.

Ask students to write a paragraph explaining whether they think the following statement is true or false: A nation's geography and culture affect the technologies developed and used in that nation. They should use information from the lesson to support their answer.

## Going Further

Have students identify other examples of ways in which technology is used differently or similarly in daily life in different cultures. A source of case studies on Japanese home life is provided in the **References** section.

Give students the following assignment: Study how energy is used in your own home in one week. Look at your home's thermostat to find out how warm or cool the temperature is kept. Is central heating or an air conditioner used to keep your home at this temperature? If your home is heated, what kind of heat do you use—gas, oil, electric, wood? What appliances does your family use every day?

With your parents' help, find utility bills for a recent month. Utility bills tell how much your family must pay for gas and electricity. By dividing the total amount of a monthly bill by four, you can get a good idea of how much money you spend on energy for your house in one week. Make a chart, poster, or mobile to illustrate how energy is used in your home.

## References

*Focus Japan* (New York: JETRO). Monthly newsletter.

*Japan: Technology and Tradition* (Chicago, IL: Society for Visual Education, n.d.). Filmstrip package.

Parisi, Lynn S., ed., *A Look at Japanese Culture Through the Family* (Boulder, CO: SSEC, 1988).

# A HEATING DEVICE FROM JAPAN

How do you think this device helps keep the family warm?

BEST COPY AVAILABLE

# KEEPING WARM IN JAPAN

Japan has very few energy resources of its own. Because it must buy energy from other countries, the cost of gasoline, electricity, and heating oil is high. The Japanese people must use energy wisely or pay huge bills.

In Japan, when people are cold, they heat their bodies first. This uses up much less energy than heating a whole room or house. The first thing Japanese people do in cold weather is bundle up with lots of clothes. They wear long underwear and several layers of shirts and sweaters.

If you visited a Japanese store, you would see many special appliances that help keep people warm. People can buy electric slippers to keep their feet warm or electric pillows to keep their heads warm. They can even buy electric pants—big balloon-like pants that are heated with electric wires. These pants keep people's legs very warm but make moving around hard. All these appliances use much less energy than heating a whole house.

One of the most popular ways to keep warm in Japan is a *kotatsu*. This is a very short table, about 1-1/2 feet high. It has a strong light beneath the middle of the table. The light gives off lots of heat. The table is covered with a blanket or quilt to keep all the heat underneath. When the Japanese sit with their legs under the table, they keep very warm.

The *kotatsu* is an old appliance. When it was first invented, it did not use light bulbs. Instead, it had a metal container filled with hot charcoal. For many years, Japanese people have gathered around the *kotatsu* to eat dinner, talk, or play games, much as Americans might sit around a fireplace.

If it is still cold in a Japanese house, the family would turn on the heat. Most houses do not have central heating. A central heating system is one that heats the whole house. Most people have small portable heaters. Some of these use electricity and some use kerosene, an inexpensive fuel. The Japanese only turn on a portable heater in one or two rooms at a time to save energy.

# Lesson C

# The Impact of the Automobile on Society: Automobility and the American Way of Life

## Introduction

James Flink, historian and critic of 20th-century American car culture, writes that automobility has had a more profound impact on Americans in the 20th century than did the frontier in the 19th century. In this lesson, students develop a historical understanding of the culture shaped by the automobile after the turn of the century. Through a background reading on the advent of the automobile, students see late 19th-century predictions of the automobile's impact on society; through a 1920s anthropological study of an American city, students view societal changes 30 years into the automobile revolution. Students then look at American society today, a century after the development of the automobile, to determine how our society has been shaped by the automobile. Finally, students imagine American society after the age of automobility has ended.

This activity focuses on HNST theme 5: science and technology influence the social, cultural, and environmental contexts within which they occur. Through the activity, students address these questions:

- How did a specific technology (the automobile) change an American town in the early 20th century?
- What has been the automobile's role in shaping American culture?
- How does the automobile continue to affect our lives in the late 20th century?

**Learning Outcomes:** Students analyze an anthropological study of an American city in the 1920s to determine societal changes since the 1890s. They discuss the impact of the automobile on aspects of society in the 1920s and then research and examine the impact of the automobile on aspects of American society in the 1990s, developing a portrait of the "car culture" in their community. Finally, they predict and describe a new transportation technology to replace the car, hypothesizing about its possible effect on American society.

**Time Required:** 2-3 class periods; homework

## Materials and Preparation

- Overhead projector
- Handouts C-1 through C-4

## Instructional Activities

Introduce the lesson by telling students that the automobile was introduced to the American public a century ago. Ask students to imagine life before the automobile. What did Americans rely on for transportation prior to the automobile? How did Americans spend leisure time?

Distribute Handout C-1. Ask students to read the handout and think about the questions at the end of the reading. Discuss the reading with students, focusing in particular on question 2 and 3. Ask students to report out 1890s predictions of the car's impact on society. Record these predictions on the board. Ask students if we have a different attitude toward technology in the late 20th century than Americans of the late 19th century had and, if so, what might be the cause of the change.

Introduce the reading from *Middletown: A Study in Modern American Culture* by Robert and Helen Lynd. Tell students that the Lynds conducted an anthropological study of a Midwestern city in the 1920s to understand how it had changed since the 1890s. Tell students they will be reading selections from *Middletown* to discover how the introduction of the automobile influenced the town's development and character.

Distribute Handout C-2 and the data retrieval chart (Handout C-3). Direct students to read the excerpts from *Middletown*. In pairs or triads, have students complete the data retrieval chart for the 1890s (pre-car society), where possible, and for the 1920s, to determine societal changes over a 30-year period.

Distribute the supplementary reading (Handout C-4) to each group or pair of students for additional information on changes in Middletown due to the automobile. Ask students to add new information to their charts from these readings. Students can distribute excerpts among group members so they do not all have to read the entire handout.

Ask students to report their findings. What impact did the automobile have on Middletown in the 30 years since the automobile was introduced?

Compare the impacts students report to the predictions of societal change from the 1890s in Handout E-1. How do the actual changes in society compare with the predictions? What conclusions can be drawn from the differences between expectations in the 1890s and the reality of the 1920s?

Now ask students to think about the role of the automobile in late 20th-century American society. Divide the class into small groups, and ask each group to consider one category from the data retrieval chart, or other categories that the groups agree upon, to understand the impact of the car in our society. Tell students they will be conducting research in their community on their category and reporting their findings back to the class to develop a community portrait of the impact of the automobile in the 1990s. (Student research may take the form of analyzing advertising, car-related news stories, number of businesses in the community related to cars, interviews with parents, grandparents, and others about changes during their lifetimes, etc. Students may write formal reports or present their findings orally; the class may create a large wall-sized chart of their findings.)

Based on their findings, ask students if they believe we live in a "car culture." Ask them to define what the phrase means to them. Is their community a part of the "car culture?"

Tell students that the adoption of any new technology by a society involves unintended consequences, both good and bad. Ask students to brainstorm some unintended consequences of replacing horses and public transportation with the automobile in the late 19th and early 20th centuries. Record student ideas on the board.

Return to question 3 in Handout C-1. Ask students if the unintended consequences listed on the board have something to do with our attitude toward the adoption of new technology today.

Assign the following essay:

> You are a historian in the year 2050, looking back at the end of the age of automobility, the late 20th century. Describe the transportation technology that replaced the car in American society, as well as American attitudes toward the adoption of this technology. In your essay, be sure to consider the impacts of the new technology on American leisure, housing patterns, social values, job opportunities, and families.

As students prepare to write their essays, remind them to think about the adoption of the car and its impact on American society in the 20th century. Will the new technology be accepted in a similar way? Why or why not?

## Going Further

Encourage students to expand their thinking to other transportation technologies. How have each of these technologies affected the economy, the environment, and society—the horse, the clipper ship, the steamship, the train, and the airplane? Which technology do students think has had the greatest impact?

Interested students might investigate whether the automobile had different effects on different groups. An interesting resource on the automobile and women is Virginia Scharff's *Taking the Wheel: Women and the Coming of the Motor Age* (Albuquerque, NM: University of New Mexico, 1992).

## References

Flink, James., *The Automobile Age* (Cambridge, MA: MIT Press, 1988).

Flink, James J., *The Car Culture* (Cambridge, MA: MIT Press, 1975).

Kunstler, James Howard, *The Geography of Nowhere* (New York: Simon and Schuster, 1993).

Lynd, Robert S., and Helen Merrill Lynd, *Middletown: A Study in Modern American Culture* (New York: Harcourt, Brace & World, 1956).

# THE ADVENT OF AUTOMOBILITY IN AMERICAN SOCIETY

The age of automobility began in the United States in 1893 when the Duryea brothers, bicycle mechanics from Springfield, Massachusetts, built the first successful American gasoline-powered car. That year, six motor vehicles were displayed and admired at the Chicago World's Fair. The years 1895 to 1899 saw the formation of an embryonic auto industry in the United States; within a decade the automobile had become an item of mass consumption. Three decades later, one out of five Americans owned a car, and the auto industry had become the United States' premier industry. Automobility re-shaped and defined American society in the 20th century.

Because the car is so intertwined with our lives in the late 20th century, it is difficult to imagine a time when Americans were not dependent on cars for transportation and recreation. What was life like before the advent of the automobile? What did the automobile replace? How did Americans respond to the automobile when it first appeared on the scene at the end of the 19th century?

By the turn of the century, many eastern American cities had built electric streetcar systems to ease traffic congestion by horse-drawn vehicles and to provide affordable mass transit for workers. Yet much of American society still relied on the horse to supply its daily transportation needs. The automobile did not initially displace the streetcar systems in American cities; it displaced the horse. The car was seen as a vast environmental improvement on horse-drawn carriages. In New York City alone at the turn of the century, horses deposited on the streets every day an estimated 2.5 million pounds of manure and 60,000 gallons of urine. Excreta from horses in the form of dried dust irritated nasal passages and lungs, then became a syrupy mass to wade through and track into the home whenever it rained. Traffic was often clogged by the carcasses of overworked dray horses who dropped in their tracks during summer heat waves or were destroyed after stumbling on slippery pavements and breaking their legs. On the average, New York City removed about 15,000 dead horses from its streets each year (Flink 1988).

The automobile was considered cleaner, safer, more reliable, and more economical than the horse. Numerous tests demonstrated to the public that the motorcar was cheaper to operate than the horse. The American public agreed: "So far as we can at present see, the displacement of the horse will cheapen living and travel, certainly not increase them" (Flink 1975).

Many Americans believed, and advertisers and auto enthusiasts supported their belief, that the automobile would improve their lives. In fact, the automobile was widely seen as the solution to a variety of social problems in the late 19th century. The magazine *Scientific American* echoed this view in an 1899 article: "The improvement in city conditions by the general adoption of the motorcar can hardly be overestimated. Streets clean, dustless and odorless, with light rubber tired vehicles moving swiftly and noiselessly over their smooth expanse, would eliminate a greater part of the nervousness, distraction, and strain of modern metropolitan life" (quoted in Flink 1975). Aside from a means to improve conditions in the city, the car was seen as a way to escape the city. The problem of urban crowding and tenement living could be solved if every worker owned a motorcar and commuted to work from suburbia:

> Imagine a healthier race of workingmen, toiling in cheerful and sanitary factories, with mechanical skill and trade-craft developed to the highest, as the machinery grows more delicate and perfect, who, in the late afternoon, glide away in their own comfortable vehicles to their little farms or houses in the country or by the sea twenty or thirty miles distant! They will be healthier, happier, more intelligent and self-respecting citizens because of the chance to live among the meadows and flowers of the country instead of in crowded city streets (quoted in Flink 1975).

Said Henry Ford, "We shall solve the city problem by leaving the city" (quoted in Flink 1975).

## Questions for Discussion:

1. What did the car symbolize for Americans in the 1890s?

2. What did people in the 1890s think the auto's impact on society would be? What is your reaction to these predictions?

3. Is there any new or emerging technology today that we see in such a positive light as Americans viewed the car in the 1890s? Why or why not?

## Resources

Flink, James J., *The Automobile Age* (Cambridge, MA: The MIT Press, 1988).

Flink, James J., *The Car Culture* (Cambridge, MA: The MIT Press, 1975).

# INVENTIONS RE-MAKING LEISURE

Although lectures, reading, music, and art are strongly intrenched in Middletown's traditions, it is none of these that would first attract the attention of a newcomer watching Middletown at play.

"Why on earth do you need to study what's changing this country?" said a lifelong resident and shrewd observer of the Middle West. "I can tell you what's happening in just four letters: A-U-T-O!"

In 1890 the possession of a pony was the wildest flight of a Middletown boy's dreams. In 1924 a Bible class teacher in a Middletown school concluded her teaching of the Creation: "And now, children, is there any of these animals that God created that man could have got along without?" One after another of the animals from goat to mosquito was mentioned and for one reason rejected; finally, "The horse!" said one boy triumphantly, and the rest of the class agreed. Ten or twelve years ago a new horse fountain was installed at the corner of the Courthouse square; now it remains dry during most of the blazing heat of a Mid-Western summer, and no one cares. The "horse culture" of Middletown has almost disappeared.

Nor was the horse culture in all the years of its undisputed sway ever as pervasive a part of the life of Middletown as is the cluster of habits that have grown up overnight around the automobile. A local carriage manufacturer of the early days estimates that about 125 families owned a horse and buggy in 1890, practically all of them business class folk. "A regular sight summer mornings was Mrs. Jim B—[the wife of one of the city's leading men] with a friend out in her rig, shelling peas for dinner while her horse ambled along the road." As spring came on each year entries like these began to appear in the diaries:

"April 1, '88. Easter. A beautiful day, cloudy at times but very warm, and much walking and riding about town."

"May 19, '89. Considerable carriage riding today."

"July 16, '89. Considerable riding this evening. People out 'cooling off'."

"September 18, '87. Wife and myself went to the Cemetery this afternoon in the buggy. Quite a number of others were placing flowers upon the graves of their dear ones...."

But if the few rode in carriages in 1890, the great mass walked. The Sunday afternoon stroll was the rule.

Meanwhile, in a Middletown machine shop a man was tinkering at a "steam wagon" which in September, 1890, was placed on the street for the first trial....

"The vehicle has the appearance of an ordinary road wagon, when put in motion," said the newspaper, "though there is no tongue attached. It is run on the principle of a railroad locomotive, a lever in front which guides the vehicle being operated by the person driving. The power is a small engine placed under the running gears and the steam is made by a small gasoline flame beneath a fuel tank. Twenty-five miles an hour can be attained with this wonderful device. The wagon will carry any load that can be placed on it, climbing hills and passing over bad roads with the same ease as over a level road. The wagon complete cost nearly $1,000."

In other cities other men were also working at these "horseless wagons." As late as 1895 Elwood Haynes of Kokomo, Indiana, one of the early tinkerers, was stopped by a policeman as he drove his horseless car into Chicago and ordered to take the thing off the streets. In 1896 the resplendent posters of the alert P.T. Barnum featured in the foreground a "horseless carriage to be seen every day in the new street parade"—with elephants, camels and all the rest of the circus lost in the background while the crowd cheers "the famous Duryea Motorwagon or Motorcycle."

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The first real automobile appeared in Middletown in 1900. About 1906 it was estimated that "there are probably 200 in the city and country." At the close of 1923 there were 6,221 passenger cars in the city, one for every 6.1 persons, or roughly two for every three families. Of these 6,221 cars, 41 per cent. were Fords; 54 per cent. of the total were cars of models of 1920 or later, and 17 per cent. models earlier than 1917. These cars average a bit over 5,000 miles a year. For some of the workers and some of the business class, use of the automobile is a seasonal matter, but the increase in surfaced roads and in closed cars is rapidly making the car a year-round tool for leisure-time as well as getting-a-living activities. As, at the turn of the century, business class people began to feel apologetic if they did not have a telephone, so ownership of an automobile has now reached the point of being an accepted essential of normal living.

Into the equilibrium of habits which constitutes for each individual some integration in living has come this new habit, upsetting old adjustments, and blasting its way through such accustomed and unquestioned dicta as "Rain or shine, I never miss a Sunday morning at church"; "A high school boy does not need much spending money"; "I don't need exercise, walking to the office keeps me fit"; "I wouldn't think of moving out of town and being so far from my friends"; "Parents ought always to know where their children are." The newcomer is most quickly and amicably incorporated into those regions of behavior in which men are engaged in doing impersonal, matter-of-fact things; much more contested is its advent where emotionally charged sanctions and taboos are concerned. No one questions the use of the auto for transporting groceries, getting to one's place of work or to the golf course, or in place of the porch for "cooling off after supper" on a hot summer evening; however much of the activities concerned with getting a living may be altered by the fact that a factory can draw from workmen within a radius of forty-five miles, or however much old labor union men resent the intrusion of this new alternate way of spending an evening, these things are hardly major issues. But when auto riding tends to replace the traditional call in the family parlor as a way of approach between the unmarried, "the home is endangered," and all-day Sunday motor trips are a "threat against the church"; it is in the activities concerned with the home and religion that the automobile occasions the greatest emotional conflicts.

Group-sanctioned values are disturbed by the inroads of the automobile upon the family budget. A case in point is the not uncommon practice of mortgaging a home to buy an automobile. Data on automobile ownership were secured from 123 working class families. Of these, sixty have cars. Forty-one of the sixty own their homes. Twenty-six of these forty-one families have mortgages on their homes. Forty of the sixty-three families who do not own a car own their homes. Twenty-nine of these have mortgages on their homes. Obviously other factors are involved in many of Middletown's mortgages. That the automobile does represent a real choice in the minds of some at least is suggested by the acid retort of one citizen to the question about car ownership: "No, sir, we've *not* got a car. *That's* why we've got a home." According to an officer of a Middletown automobile financing company, 75 to 90 per cent. of the cars purchased locally are bought on time payment, and a working man earning $35.00 a week frequently plans to use one week's pay each month as payment for his car.

The automobile has apparently unsettled the habit of careful saving for some families. "Part of the money we spend on the car would go to the bank, I suppose" said more than one working class wife. A business man explained his recent invitation of social oblivion by selling his car by saying: "My car, counting depreciation and everything, was costing mightily nearly $100.00 a month, and my wife and I sat down together the other night and just figured that we're getting along, and if we're to have anything later on, we've just got to begin to save." The "moral" aspect of the competition between the automobile and certain accepted expenditures appears in the remark of another business man, "An automobile is a luxury, and no one has a right to one if he can't afford it. I haven't the slightest sympathy for any one who is out of work if he owns a car."

Men in the clothing industry are convinced that automobiles are bought at the expense of clothing, and the statements of a number of the working class wives bear this out:

"We'd rather do without clothes than give up the car," said one mother of nine children. "We used to go to his sister's to visit, but by the time we'd get the children shoed and dressed there wasn't any money left for carfare. Now no matter how they look, we just poke 'em in the car and take 'em along."

"We don't have no fancy clothes when we have the car to pay for," said another. "The car is the only pleasure we have."

Even food may suffer:

"I'll go without food before I'll see us give up the car," said one woman emphatically, and several who were out of work were apparently making precisely this adjustment.

Twenty-one of the twenty-six families owning a car for whom data on bathroom facilities happened to be secured live in homes without bathtubs. Here we obviously have a new habit cutting in ahead of an older one and slowing down the diffusion of the latter.

Meanwhile, advertisements pound away at Middletown people with the tempting advice to spend money for automobiles for the sake of their homes and families:

"Hit the trail to better times!" says one such advertisement.

Another depicts a gray-haired banker lending a young couple the money to buy a car and proffering the friendly advice: "Before you can save money, you first must make money. And to make it you must have health, contentment, and full command of all your resources....I have often advised customers of mine to buy cars, as I felt that the increased stimulation and opportunity of observation would enable them to earn amounts equal to the cost of their cars."

Many families feel that an automobile is justified as an agency holding the family group together. "I never feel as close to my family as when we are all together in the car," said one business class mother, and one or two spoke of giving up Country Club membership or other recreations to get a car for this reason. "We don't spend anything on recreation except for the car. We save every place we can and put the money into the car. It keeps the family together," was an opinion voiced more than once. Sixty-one per cent. of 337 boys and 60 per cent. of 423 girls in the three upper years of the high school say that they motor more often with their parents than without them.

But this centralizing tendency of the automobile may be only a passing phase; sets in the other direction are almost equally prominent. "Our daughters [eighteen and fifteen] don't use our car much because they are always with somebody else in their car when we go out motoring," lamented one business class mother. And another said, "the two older children [eighteen and sixteen] never go out when the family motors. They always have something else on." "In the nineties we were all much more together," said another wife. "People brought chairs and cushions out of the house and sat on the lawn evenings. We rolled out a strip of carpet and put cushions on the porch step to take care of the unlimited overflow of neighbors that dropped by. We'd sit out so all evening. The younger couples perhaps would wander off for half an hour to get a soda but come back to join in the informal singing or listen while somebody strummed a mandolin or guitar." "What on earth *do* you want me to do? Just sit around home all evening!" retorted a popular high school girl of today when her father discouraged her going out motoring for the evening with a young blade in a rakish car waiting at the curb. The fact that 348 boys and 382 girls in the three upper years of the high school placed "use of the automobile" fifth and fourth respectively in a list of twelve possible sources of disagreement between them and their parents suggests that this may be an increasing decentralizing agent.

An earnest teacher in a Sunday School class of working class boys and girls in their late teens was winding up the lesson on the temptation of Jesus: "These three temptations summarize all the temptations we encounter today: physical comfort, fame, and wealth. Can you think of any temptation we have today that Jesus didn't have?" "Speed!" rejoined one boy. The unwanted interruption was quickly passed over. But the boy had mentioned a tendency underlying one of the four chief infringements of group laws in Middletown today, and the manifestations of Speed are not confined to "speeding." "Auto Polo next Sunday!!" shouts the display advertisement of an amusement park near the city. "It's motor insanity—too fast for the movies!" The boys who have cars "step on the gas," and those who haven't cars sometimes steal them: "The desire of youth to step on the gas when it has no machine of its own," said the local press, "is considered responsible for the theft of the greater part of the [154] automobiles stolen from [Middletown] during the past year."

The threat which the automobile presents to some anxious parents is suggested by the fact that of the thirty girls brought before the juvenile court in the twelve months preceding September 1, 1924, charged with "sex crimes," for whom the place where the offense occurred was given in the records, nineteen were listed as having

committed the offense in an automobile. Here again the automobile appears to some as an "enemy" of the home and society.

Sharp, also, is the resentment aroused by this elbowing new device when it interferes with old-established religious habits. The minister trying to change people's behavior in desired directions through the spoken word must compete against the strong pull of the open road strengthened by endless printed "copy" inciting to travel. Preaching to 200 people on a hot, sunny Sunday in midsummer on "The Supreme Need of Today," a leading Middletown minister denounced "automobilitis—the thing those people have who go off motoring on Sunday instead of going to church. If you want to use your car on Sunday, take it out Sunday morning and bring some shut-ins to church and Sunday School; then in the afternoon, if you choose, go out and worship God in the beauty of nature—but don't neglect to worship Him indoors too." This same month there appeared in the *Saturday Evening Post*, reaching approximately one family in six in Middletown, a two-page spread on the automobile as an "enricher of life," quoting "a bank president in a Mid-Western city" as saying, "A man who works six days a week and spends the seventh on his own doorstep certainly will not pick up the extra dimes in the greatest thoroughfares of life." "Some sunny Sunday very soon," said another two-page spread in the *Post*, "just drive an Overland up to your door—tell the family to hurry the packing and get aboard—and be off with smiles down the nearest road—free, loose, and happy—bound for green wonderlands." Another such advertisement urged Middletown to "Increase Your Week-End Touring Radius." If we except the concentrated group pressure of war time, never perhaps since the days of the camp-meeting have the citizens of this community been subjected to such a powerfully focused stream of habit diffusion. To get the full force of this appeal, one must remember that the nearest lakes or hills are one hundred miles from Middletown in either direction and that an afternoon's motoring brings only mile upon mile of level stretches like Middletown itself.

"We had a fine day yesterday," exclaimed an elderly pillar of a prominent church, by way of Monday morning greeting. "We left home at five in the morning. By seven we swept into _____. At eight we had breakfast at ____, eighty miles from home. From there we went on to Lake ____, the longest in the state. I had never seen it before, and I've lived here all my life, but I sure do want to go again. Then we went to ____ [the Y.M.C.A. camp] and had our chicken dinner. It's a fine thing for people to get out that way on Sundays. No question about it. They see different things and get a larger outlook."

"Did you miss church?" he was asked.

"Yes, I did, but you can't do both. I never missed church or Sunday School for thirteen years and I kind of feel as if I'd done my share. The ministers ought not to rail against people's driving on Sunday. They ought just to realize that they won't be there every Sunday during the summer, and make church interesting enough so they'll want to come."

But if the automobile touches the rest of Middletown's living at many points, it has revolutionized its leisure; more, perhaps, than the movies or any other intrusion new to Middletown since the nineties, it is making leisure-time enjoyment a regularly expected part of every day and week rather than an occasional event. The readily available leisure-time options of even the working class have been multiplied many-fold. As one working class housewife remarked, "We just go to lots of things we couldn't go to if we didn't have a car." Beefsteak and watermelon picnics in a park or a near-by wood can be a matter of a moment's decision on a hot afternoon.

Not only has walking for pleasure become practically extinct, but the occasional event such as a parade on a holiday attracts far less attention now.

"Lots of noise on the street preparing for the 4th," reports the diary of a Middletown merchant on July 3, 1891. And on the 4th: "The town full of people—grand parade with representatives of different trades, an ox roasted whole, four bands, fireworks, races, greased pig, dancing all day, etc." An account in '93 reports: "Quite a stir in town. Firecrackers going off all night and all this day—big horse racing at the Fair Ground. Stores all closed this afternoon. Fireworks at the Fair Ground this evening."

Today the week before the Fourth brings a pale edition of the earlier din, continuing until the night before. But the Fourth dawns quietly on an empty city; Middletown has taken to the road. Memorial Day and Labor Day are likewise short on their earlier glory.

Use of the automobile has apparently been influential in spreading the "vacation" habit. The custom of having each summer a respite, usually of two weeks, from getting-a-living activities, with pay unabated, is increasingly common among the business class, but it is as yet very uncommon among the workers. "Vacations in 1890?" echoed one substantial citizen. "Why, the word wasn't in the dictionary!" "Executives of the 1890 period never took a vacation," said another man of a type common in Middletown thirty-five years ago, who used to announce proudly that they had "not missed a day's work in twenty years." Vacations there were in the nineties, nevertheless, particularly for the wives and children of those business folk who had most financial leeway. Put-In Bay, Chautauqua, country boarding-houses where the rates were $5.00 a week for adults and $3.00 for children, the annual conference of the State Baptist Association, the Annual National Christian Endeavor Convention, the annual G.A.R. encampment, all drew people from Middletown. But these affected almost entirely business class people. A check of the habits of the parents of the 124 working class wives shows that summer vacations were almost unknown among this large section of the population in the nineties. In lieu of vacations both for workers and many of the business class there were excursions: those crowded, grimy, exuberant, banana-smelling affairs on which one sat up nights in a day coach, or, if a "dude," took a sleeper, from Saturday till Monday morning, and went back to work a bit seedy from loss of sleep but full of the glamour of Petoskey, or the ball game at Chicago. Two hundred and twelve people from Middletown went to Chicago in one week-end to one such excursion. One hundred and fifty journeyed to the state capital to see the unveiling of a monument to an ex-governor—"a statesman," as they called them in those days. Even train excursions to towns fifteen, twenty, and forty miles away were great events, and people reported having "seen the sights" of these other Middletowns with much enthusiasm.

Today a few plants close for one or two weeks each summer, allowing their workers an annual "vacation" without pay. Others do not close down, but workers "can usually take not over two weeks off without pay and have their jobs back when they return." Foremen in many plants get one or two weeks with pay. Of the 122 working class families giving information on this point, five families took one week off in 1923 and again in 1924, seven others took something over a week in each year, twelve took a week or more in only one of the two years. No others had as extensive vacations as these twenty-four, although other entire families took less than a week in one or both years, and in other cases some members of the families took vacations of varying lengths. Of the 100 families for whom income distribution was secured, thirty-four reported money spent on vacations; the amounts ranged from $1.49 to $175.00, averaging $24.12.

But even short trips are still beyond the horizon of many workers' families, as such comments as the following show:

"We haven't had a vacation in five years. He got a day off to paint the house, and other year they gave him two hours off to get the deed to the house signed."

"Never had a vacation in my life, honey!"

"Can't afford one this year because we're repairing the house."

"I don't know what a vacation is—I haven't had one for so long."

"We like to get out in the car each week for half a day but can't afford a longer vacation."

But the automobile is extending the radius of those who are allowed vacations with pay and is putting short trips within the reach of some for whom such vacations are still "not in the dictionary."

"The only vacation we've had in twenty years was three days we took off last year to go to Benton Harbor with my brother-in-law," said one woman, proudly recounting her trip. "We had two Fords. The women slept in the cars, the men on boards between the two running boards. Here's a picture of the two cars, taken just as the sun was coming up. See the shadows? And there's a *hill* back of them."

# THE IMPACT OF THE AUTOMOBILE ON SOCIETY

| | Transportation | Leisure | Housing Patterns | Social Norms and Values |
|---|---|---|---|---|
| 1890s (pre-automobile society) | | | | |
| 1920s | | | | |
| 1990s | | | | |

| | Job Opportunities | Family Relationships | Other(s) |
|---|---|---|---|
| 1890s (pre-automobile society) | | | |
| 1920s | | | |
| 1990s | | | |

# EXCERPTS FROM *MIDDLETOWN*

## Getting a Living: The Long Arm of the Job

The mobility afforded by new modes of transportation combines with these periodic waves of employment, unemployment, and reemployment to diminish the tendency of the workers in a given factory to live together immediately about the plant. Everybody in Middletown in 1890 got to work by walking, and workers tended to settle in the immediate neighborhood of a given factory; as a new factory was located on the outskirts of the community it formed a magnet drawing new dwellings close about it. Today, when one gets about the city and the country surrounding it by bicycle, fifteen-minute street-car service, regular bus service, and five interurban lines, and approximately two out of every three families in the city own a passenger automobile, decentralization of residence is apparent. A check of the residences of all workers in the shops of three local plants, a total of 2,171, showed that 28 per cent. lived within one-half mile of their places of work and 55 per cent. less than a mile away, while 45 per cent. lived a mile or more away; 20 per cent. of the men lived outside the city and from three to forty-five miles away, and 14 per cent. of the women lived from three to nineteen miles away. Two of the plants are old industries that have been in Middletown since gas boom days, while the third is a modern machine shop, located in Middletown more than a decade, of the sort that today dominates the city's industrial life. In the latter only 19 per cent. lived within one-half mile and only 43 per cent. within a mile, while 57 per cent. live over a mile away, and 29 per cent. of the males lived three to forty-five miles away, the number of women employed being negligible.

This trend toward decentralization of workers' dwellings means that instead of a family's activities in getting a living, making a home, play, church-going, and so on, largely overlapping and bolstering each other, one's neighbors may work at shops at the other end of the city, while those with whom one works may have their homes and other interests anywhere from one to two-score miles distant.

* * * * *

New technical developments such as the automobile and multiplied uses of electricity have opened new doors for some working men, enabling them to become owners of garages, filling stations, or electrical shops. The sharp increase in size, complexity, and cost of the modern machine-equipped shop, however, makes the process of launching out for oneself as a small manufacturer somewhat more difficult than a generation ago.

## Making a Home: Child-Rearing

"We haven't solved the problem," said another conscientious mother. "Last year we seriously considered sending our daughter away to school to get away from this social life. We try to make home as much a center as possible and keep refreshments on hand so that the children can entertain their friends here, but it isn't of much use any more. There is always some party or dance going on in a hotel or some other public place. We don't like the children to go out on school nights, but it's hard always to refuse. Last night it was a Halowe'en party at the church and tonight a dramatic club dance at the high school. Even as it is, we're a good deal worried about her; she's beginning to feel different from the others because she is more restricted and not allowed to go out as much as they do."

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Almost every mother tells of compromise somewhere. "I never would have believed I would have let my daughter join so many clubs," said one thoughtful mother of a high school girl. "I have always criticized people who did it. But when it comes right down to it, I want to minimize the boy interest, and filling her life full of other things seems to be the only way to do that. She belongs to three high school clubs besides the Matinee Musicale and a Y.W.C.A. club."

Another woman, criticized by her neighbors for letting her children "run wild," insists that the only difference between her and other mothers is that she knows where her children are and the other mothers don't: "I wish you could know the number of girls who come over here and then go to _____ [a much-criticized public dance resort fifteen miles away]. They say, 'Well, it's perfectly all right if you keep with your own crowd, but I can't explain it to mother, so I just don't tell her'."

One working class mother said that she no longer let her children go to church on Sunday evening "because that's just an excuse to get out-of-doors and away from home."

Later nights away from home bring further points of strain over grades at school and use of the car. The former is ranked by both boys and girls as third among the sources of disagreement with their parents.

"That crowd of girls was as fine as any in school two years ago," lamented one high school teacher. "Now they all belong to two or three clubs and come to me morning after morning, heavy-eyed, with work not done, and tell of being up until twelve or one the night before. Their parties used to begin earlier and end earlier, but now it isn't a party if it breaks up before midnight."

Use of the automobile ranks fifth among the boys and fourth among the girls as a source of disagreement. The extensive use of the new tool by the young has enormously extended their mobility and the range of alternatives before them; joining a crowd motoring over to dance in a town twenty miles away may be a matter of a moment's decision, with no one's permission asked. Furthermore, among the high school set, ownership of a car by one's family has become an important criterion of social fitness: a boy almost never takes a girl to a dance except in a car; there are persistent rumors of the buying of a car by local families to help their children's social standing in high school.

The more sophisticated social life of today has brought with it another "problem" much discussed by Middletown parents, the apparently increasing relaxation of some of the traditional prohibitions upon the approaches of boys and girls to each other's persons. Here again new inventions of the last thirty-five years have played a part; in 1890 a "well-brought-up" boy and girl were commonly forbidden to sit together in the dark; but motion pictures and the automobile have lifted this taboo, and once lifted, it is easy for the practice to become widely extended. Buggy-riding in 1890 allowed only a narrow range of mobility; three to eight were generally accepted hours for riding, and being out after eight-thirty without a chaperon was largely forbidden. In an auto, however, a party may go to a city halfway across the state in an afternoon or evening, and unchaperoned automobile parties as late as midnight, while subject to criticism, are not exceptional. The wide circulation among high school students of magazines of the *True Story* variety and the constant witnessing of "sex films" tend to render familiar postures and episodes taken much less for granted in a period lacking these channels of vivid diffusion.

The relaxing of parental control combines with the decrease in group parties to further the greater exclusiveness of an individual couple. In the nineties, according to those who were in high school then, "We all went to parties together and came home together. If any couple did pair off, they were considered rather a joke." Today the press accounts of high school club dances are careful to emphasize the escort of each girl attending. The number of separate dances at a dance is smaller and there is much more tendency for each individual to dance with fewer partners, in some cases to dance the entire evening with one person."When you spend four or five dollars to drag a girl to a dance," as one boy put it, "you don't want her to spend the evening dancing with every one else."

In such a grown-up atmosphere it is hardly surprising that the approaches of the sexes seem to be becoming franker. Forty-eight per cent. of 241 junior and senior boys and 51 per cent. of 315 junior and senior girls marked "true" the extreme statement, "Nine out of every ten boys and girls of high school age have 'petting parties'." In the questionnaire given to sophomores, juniors, and seniors, 44 per cent. of the 405 boys answering the questionnaire (88 per cent. of the 201 answering this question) and 34 per cent. of the 464 girls answering the question-

naire (78 per cent. of the 205 answering this question) signified that they had taken part in a "petting party" by checking one or another of the reasons listed for doing so—though, of course, data of this sort are peculiarly open to error.

## Specialization in Auto Production

Even more characteristic perhaps of the machine age in Middletown is the high speed specialization of the several automobile part plants. Having in this new automobile industry little previous heritage of plant and machinery, the planning and control of the engineer have had a clear field for the introduction of machine production methods. Specialization in tool processes is proceeding rapidly. Here, for instance, is what a typical worker in a local plant making automobile parts does to get a living. The worker is drilling metal joint rings for the front of a well-known automobile. He stands all day in front of his multiple drill-press, undrilled rings being brought constantly to his elbow and his product carted away. Three times each minute, nine hours a day, he does the following set of things: He picks up two joint rings with his left hand, inserts them in his iron man with both hands, turns two levers waist-high with both hands to close jigs, pushes up shoulder-high lever with right hand, takes hold of levers at waist line with both hands and turns the rotating table with its four jigs half-way round, pulls shoulder-high lever with right hand, pulls shoulder-high lever with left hand, removes the two rings which have been drilled with right hand, while he picks up two new rings with his left hand, inserts the two new rings into the drill press with both hands—and does the process all over again.

Lesson D

# Paper Clip Lifters

## Introduction

This activity, which focuses on HNST theme 2, gives students an opportunity to experience how they can exercise their creativity while building a technological device. The activity also provides an opportunity to elaborate the nature of technology because students reflect on the criteria they have used to evaluate the technologies they developed.

**Learning Outcomes:** By the end of this investigation, students should be able to construct an energy transforming system. They will demonstrate their ability by designing a system that uses a spinning motion to lift a container filled with paper clips at least 20 cm off the floor, constructing their system using a variety of simple materials, testing and revising their system, and demonstrating and describing their system to the class. Students should also understand that we can use a variety of energy sources to accomplish a certain task, demonstrating their understanding by comparing their system to the different systems designed by their classmates, and describing the energy sources that were the most and least effective at accomplishing the given task.

**Time Required:** 2 to 3 class periods

## Materials and Preparation:

- 10 boxes of paper clips
- 10 small paper cups (or Styrofoam™ bowls)
- 1 hand-cranked generator with alligator clips
- 2 electric fans, 12-V
- 6 alligator clips
- 10 pairs of scissors
- 31 pairs of goggles
- At least 3 blow dryers
- At least 20 cups or bowls—Styrofoam™, paper, or plastic
- At least 10 aluminum pie pans
- At least 1 roll of aluminum foil
- At least 1 roll of plastic wrap
- At least 5 shoe boxes
- At least 1 box of plastic straws

- At least 10 cans of various sizes
- Several stacks of newspaper
- 1 roll of waxed paper
- At least 20 sheets of construction paper
- At least 2 sheets of poster board
- 2 rolls of masking tape
- 1 box of rubber bands
- At least 5 plastic bottles
- Copies of Handouts D-1, D-2, and D-3

Begin collecting materials for this investigation as soon as possible. Most of these materials are everyday items that students can bring from home. If the students do bring materials to class, be sure that you check for safety hazards such as loose, frayed, or exposed electrical wires; sharp edges or points; or breakable parts.

You might want to substitute small Styrofoam™ bowls for the paper cups that the students will use to hold the paper clips. Depending on the brand you use, these bowls may hold up better than paper cups.

## Instructional Activities

Ask students to think about a technology that they would like to own or that they especially enjoy using. What qualities of this technology do they like—its function, efficiency, creativity, beauty? List a number of qualities of technologies that students value on the chalkboard.

Display the supplies you have gathered and tell students that they are going to use these materials to create a technology. Here is the challenge: The technology must be capable of lifting paper clips and must meet the following criteria and constraints:

- The system must use a spinning motion to lift a container of paper clips.
- The system must lift the paper clips at least 20 centimeters off a table or the floor.
- The container must be a small paper cup.
- The energy input to the system cannot be the movement of a human hand.

Conduct a brainstorming session to list possible ways to build such a system.

Divide the class into teams of two, three, or four and let them begin planning their systems. As each team finishes its plan, check it for safety and practicability. You may wish to distribute Handout D-1 to emphasize the guidelines for safety.

Provide lots of time for teams to work on their projects, and set aside time for the teams to demonstrate their systems.

After all the demonstrations are complete, have the students respond to the questions on Handout D-2. With the class, develop a list of criteria that may be used to evaluate a technology, in addition to whether it works. These might include the creativity of the design, the beauty of the finished product, the safety of the product (both to its users and to its environment), efficient use of materials, and the like. What criteria are most important? Why? Which of these criteria were uppermost in students' minds when they were designing their technologies? Which might become more important if they were to refine their designs?

Distribute Handout D-3 and have students compare their list of criteria for evaluating technology with those of an expert. Is there anything on the expert's list they would add to their list? If there are items on their list that the historian did not include, how would they justify those criteria to the expert?

To conclude the lesson, ask students to apply their list of criteria to a technology they have used in the past week. Each students should write a paragraph explaining his/her evaluation of the technology based on the criteria; each student should also write a second paragraph reflecting on whether they would answer the lesson-opening question differently as a result of their participation in this lesson.

## Going Further

A useful follow-up to this lesson would be a panel discussion with inventors from your area. To be most effective, the panel should include people who have developed both "high" and "low" technologies, as well as people who worked independently and those who worked in industrial or university research settings. Three or four panelists should be sufficient to provide some variety in the problems the technologies solved and the ways in which the individuals approached the problem to be solved. Although a more open-ended structure is possible, it works fairly well to ask each inventor to provide a 5- to 10-minute overview of their inventions, followed by a general question-and-answer period. Have students develop some organizing questions for the panelists; some possibilities include the following:

- What problem does your invention solve?
- How did you identify the problem?
- How did you develop the solution? How did you test your idea? What were the most important criteria in deciding whether your invention was a good one?
- Is your technology readily available? Why or why not?

Following the question-and-answer period, hold a discussion with students regarding what the panel showed about the nature of technology. The discussion might focus on such questions as:

- How is creating technology in an industrial setting different than when done individually? Are the important criteria different in the two settings?
- What are some of the different sources of creative technological solutions?
- How would we evaluate the "success" of these technologies?
- What factors influence whether a technology becomes widely available and widely used? Could we predict the success of technologies based on our criteria for "good" technologies? Why or why not?

This activity could fit into a unit on simple machines. One book that can provide additional examples of how technology works is David Macaulay's *The Way Things Work* (Boston: Houghton Mifflin, 1988).

# SAFETY GUIDELINES

Answer the following questions. If you answer "yes" to any of these questions, you must revise your system.

1. Does the system contain any sharp edges or points that could hurt someone?

2. Does the system contain any loose objects or pieces that could fly off and hurt someone while the system is operating?

3. Does the system contain water that spills out or otherwise causes slippery surfaces?

4. Does the system contain any hot surfaces or produce large amounts of heat that could hurt someone?

5. Does the system contain any exposed electrical wires or any wires or electrical appliances that might come into contact with water and create an electrical hazard?

Remember, all team members must wear eye protection and stand a safe distance away from the system.

# EVALUATING TECHNOLOGY

Compare all of your classmates' systems and answer the following questions:

1. Which energy input generally lifted the most paper clips?

2. Which energy input seemed to be the easiest to use?

3. What problem was your team's technological system supposed to solve?

4. What energy transformations took place in your system?

5. What were the energy input and the output from your team's system?

6. Explain whether your team's system met your design criteria as well as you expected it would.

7. If you had another chance, how would you modify your team's system?

8. Which team's system seemed to be the most efficient?

9. Which team's system would you judge to be the best? By what criteria or standards?

# CRITERIA FOR EVALUATING TECHNOLOGIES

The following list of criteria for evaluating technologies was developed by someone who has studied technology for many years. Compare the list with the one you and your classmates developed. Would you add anything from this list to yours? How would you convince this "expert" that an item on your list should be added to this handout?

- Workability. Does the technology work? Does it solve the problem it was designed to solve?
- Durability and strength of materials. Will the technology last, or will it wear out easily?
- Cost. Can the technology be produced for a reasonable amount of money? Will users be able to obtain the technology at a reasonable cost?
- Aesthetics. Is the technology aesthetically pleasing? That is, is it pleasing to the senses? Is it beautiful?
- Efficiency. Is the technology efficient? Does it use minimal amounts of energy? Does it use the smallest amount of energy possible to achieve its purpose?
- Safety. Is the technology safe for its users, society, and the environment?
- Compatibility with values. Does creation or use of the technology violate any important values of our society?
- Creativity. Does the design reflect a new approach to a problem? Did the designer take a new approach to a problem? to the solution?

Lesson E

# Rachel Carson's Work: A Historical View of Population Dynamics

## Introduction

This activity uses historical examples from the field of ecology to illustrate the effects of varied technologies on the aquatic environment and the resulting cultural and societal impacts (HNST theme 5). Students will get a sense of what a population is and how a variety of factors affect the stability of a population and our ability to detect changes in that population.

The activity is divided into two parts. In Part A, the students use the software program *Fish Banks, Ltd.*, which provides the opportunity for teams of students to simulate their own fishing company and see the results of their decisions. Students conclude this portion of the activity by using data from historical examples. In Part B, students make use of the fish population studies described in Rachel Carson's *Silent Spring*. Although the two parts of the activity are related, you can conduct each independently.

## Time Required: 3-5 hours

**Learning Outcomes:** By discussing historical data from *Silent Spring* and participating in a computer simulation, students develop a better sense of factors that affect animal populations in aquatic environments. Students will also be able to use historical examples to illustrate benefits and costs of technology and illustrate the connections among technology, society, and the environment. Choosing to use *Fish Banks, Ltd.* will provide the opportunity for the students to use computers as a tool for modeling or simulating a real-life situation. The **Going Further** activities highlight the contributions that female scientists have made to the field of ecology.

## Materials and Preparation

**Part A (Optional)**

- 1 computer
- *Fish Banks, Ltd.* software
- Handouts E-1 and E-2
- World map

**Part B**

- Classroom set of *Silent Spring*, or reprints of Chapter 9
- World map and U.S. political map
- Handout E-3

The *Fish Banks, Ltd.* program can be ordered from Laboratory for Interactive Learning, Institute for Policy and Social Science Research, Hood House, University of New Hampshire, Durham, NH 03824. Phone: (603) 862-2156 Fax: (603) 862-1488. Be certain to request the disk size (3.5 or 5.25 inch) that is appropriate for your computer. You should conduct a test run of the program before using it with the class. You will also need to make handouts and transparencies for the debriefing session, using the masters provided with the program.

Plan your students' working groups (e.g., six groups of five each).

## Instructional Activities

### Part A (Optional)

Pose the following dilemma to students: In 1990, the total global fish catch declined for the first time in 13 years. What might be some reasons for the decline? Post students' responses on the chalkboard.

Tell students that for the next several class periods, they will be taking the role of fishing companies. This experience will help them evaluate the responses they have listed on the chalkboard.

Divide the students into six teams of five students to review the instructions for *Fish Banks, Ltd.* One possible division of labor among group members is the following: (1) role descriptions, (2) bank balance, (3) ships, (4) fish, and (5) terms and steps of play.

After the teams have read their instructions, have them share their information according to the guidelines on Handout E-1.

To garner enthusiasm for the simulation, encourage students to choose names for their teams. Some possibilities include:

- Supreme Fishing Industries (We feed the world!), Frigid, Iceland
- Quality Fish Company, Utopia, Atlantis
- Maximum Catch Fish Company, United Fishing States
- Charlie's Fish Company, Tuna Bay, Hardrock Republic
- North Atlantic Fleet Fisheries, Hidden Bay, Northland
- Quality Fish Company, Fishing Isles.

Run the software. Have teams enter their choices on the decision sheet provided with the software. Then either you or a student can enter the numbers for each year's fishing strategies.

Print the team results after 10 years of fishing. Provide students with Handout E-2 and ask them to work in their teams to answer the questions.

Debrief the activity using the transparencies from *Fish Banks* that show the history of the Peruvian anchovy and Pacific sardine fishing industries. The transparencies of the components of the fisheries system may also be useful. Be sure to discuss how changing technologies in the fishing industry have created larger effects on the environment. Also, return to the answers students gave to the original dilemma and ask students to reflect on whether the simulation helps them evaluate any of their responses.

## Part B

If you have conducted Part A of the lesson, inform students that they are going to be looking at another human activity that has affected fish populations. If you have access to the PBS video *Rachel Carson's Silent Spring* (see Chapter 5 for more information), you may wish to show clips to engage student interest in Carson and her work. As an alternative, choose one illustrative paragraph from Chapter 9 of *Silent Spring* and read it aloud to your students. The section about the use of dieldrin to kill the sandfly is particularly good. It begins: "The minimum immediate over-all kill throughout the marshes, excluding the Indian River shoreline, was 20-30 tons of fishes, or about 1,175,000 fishes..."

Divide the class into pairs of students and distribute one copy of Handout E-3 to each pair. The students should use Chapter 9 and the maps you make available to answer the questions.

For your information, Carson describes 17 examples. The primary example is the salmon population in the northeast. Carson describes a variety of fish: salmon, trout, catfish, sunfish, milkfish and the organisms that interact with and are dependent upon them. She also describes other marine life such as shrimp and oyster. Shrimp are killed by pesticides such as endrin at concentrations of one-half part per billion; molluscs survive and eat the remains of fish and crustaceans, but concentrate the pesticide in their tissues. Carson's examples are drawn from a variety of regions in the United States and around the world: the north Atlantic, Oklahoma, Florida, California, Texas, and the Rocky Mountains of Montana. Her examples from Asia (China, Philippines, Thailand, India) and Central Africa indicate staggering numbers of fish lost to pesticides as well. Pesticides were used in unsuccessful attempts to eliminate these pests: spruce budworm (DDT), fire ants (heptachlor and dieldrin), mice (endrin), riceleaf miner (dieldrin), boll weevil (toxaphene), sandfly (dieldrin), mosquito (DDT).

After each team has completed its reading and analysis of Chapter 9, conduct a class discussion based on the following questions:

- Why would one year's data not be sufficient to draw conclusions about the effects of a technology on a fish population? (Use the information you have both from *Silent Spring* and *Fish Banks Ltd.*)

  [One year's data would not be sufficient in the case of *Fish Banks* because when populations are depleted in one area, fish sometimes move in from another area. Until both areas are compared over time, the depletion does not become apparent. In the case that Carson describes, the salmon (for example) have a multi-year life cycle. The fish in their first year are dependent upon different species of insects than those in their second year are, and so on. So if the pesticide eliminated all species of insect that the two-year-old fish required, that year's population would be lost. The population would still have a chance to recover if the insects had returned by the following year.]

- How did the technologies you learned about affect the environment? How could their use affect society?

  [The fisheries technology (as its size increased) took fish from the environment faster than the population could regenerate itself. The pesticides had a much broader effect, because they killed food supplies (insects), poisoned some larger animals, and remained concentrated in the tissues of larger animals. If improperly used, both technologies would have very negative effects on society because human beings would lose an industry and a variety of food sources.]

- Do Carson's examples support her arguments?

  [The fact that Carson's book is still in print is probably the best indicator that her examples do support her arguments. The extent of case studies in the book and the 25+ pages of principal sources indicate the extent of her research. The objection posed by some critics is that her style was dramatic. But time has shown her conclusions to be valid. For example, salmon in the northeastern United States are still endangered today; the remaining salmon population in Maine is estimated at 5000, a fraction of their former number.]

As an evaluation activity, ask students to create a cartoon, poster, or editorial conveying their ideas about the impact of technology on marine environments, drawing on what they learned from both the simulation and the Carson reading. Their work should include their thinking on unintended consequences and how users of technology could become more aware of the consequences of their actions.

## Going Further

Have students read other chapters in *Silent Spring*. For example, Chapter 2 describes the types of pesticides and their composition. The remaining 15 chapters are case studies of other populations and ecosystems affected by pesticides. This is relevant information even today, because the pesticides Carson described in 1962 (such as 2-4-5t and malathion) are still widely used outside the United States, particularly in tropical countries, some of which export beef and fruit to the United States.

Consider adding other books about Rachel Carson's work to the lesson so students can see the effect of her work. One possibility is *Since Silent Spring*, by Frank Graham, Jr. (Boston: Houghton Mifflin, 1970). Students today may not realize the extent of damage caused by chemicals like DDT or may think DDT was banned immediately after Carson's work was published. This was not the case. Many researchers and activists jeopardized their careers by arguing for laws that banned DDT. Graham documents that work, which was still going on in the 1970s.

Organize your students to begin observational field studies. For example, students might monitor the bird populations in a specific area or conduct an insect count. As they collect their data, it will become apparent how comprehensive Carson's work was. For an update on the specific populations that Carson studied, see *Newsweek*, "Averting Death Foretold," November 28, 1994, pages 72-73.

Work with a language arts teacher and coordinate a project in which students read John Steinbeck's *Cannery Row*.

Make use of *Science Is Women's Work: Photographs and Biographies of American Women in the Sciences*. This paperback booklet is available for a modest price from the National Women's History Project, 7738 Bell Road, Windsor, CA 95492. Phone: (707) 838-6000. This booklet describes such scientists as Rachel Carson and Ellen Swallow Richards, the 19th-century biologist and chemist who taught chemistry at MIT, founded the Woods Hole Marine Biological Laboratory, and was the first to use the word *ecology*, which comes from the Greek word for household, the place where women in Richards' time were supposed to confine their work.

Show the PBS video on Rachel Carson from the American Experience series (see Chapter 5 for more information). The video could serve as a springboard for discussion of the attacks on Carson and her work following the publication of *Silent Spring*. These attacks came from scientists working in the chemical industry and parts of the food industry, as well as from such magazines as *Time* and *Newsweek*. Many of the criticisms were directed at Carson as a woman, rather than a scientist, with critics using such adjectives as hysterical and beyond-the-fringe to describe her. As nonbiased scientists reviewed her work, however, they found it to be well researched and endorsed her overall premise—that pesticides endangered the environment and should be proven safe before being used.

# GUIDELINES FOR SHARING INFORMATION

1. Each team member will receive a set of directions related to *Fish Banks, Ltd.* The directions provide information needed to operate your fish company. No two members will have the same information! You can only provide information verbally; you cannot show someone else what is on your data sheet. There are two exceptions to this rule:
   - Team member #5 can share the *Decision Sheet* with the other team members, as they have to help make the team decisions and record them on this sheet.
   - Team member #3 can share the *Team Strategy Worksheet* with all team members, as the team decides fleet allocations and ship purchases and sales.
2. Read your set of directions and then meet and discuss your reading with your team members. Make sure that everyone understands what your team is supposed to do in this activity. If you do not understand something, chances are that others do not understand it either.
3. Once you are ready to begin operating your fishing fleet, check with the instructor for the status report for year one. Your team will present your Decision Sheet to the instructor once each year, and then receive data from the instructor that you will record and use to make decisions for the next year.

# *FISH BANKS* DISCUSSION QUESTIONS

Discuss the following questions with your teammates; then record your responses in the space provided.

1. What problems and events occurred during this game?

2. Do we have problems like this in the real world?

3. What factors in the game were responsible for the problems and events?

4. How might these be related to real systems?

5. How could we avoid these problems in future games?

6. Could we solve these problems in real systems?

# *SILENT SPRING* DISCUSSION QUESTIONS

Discuss the following questions with your teammates; then record your responses in the space provided.

1. How many examples or cases does Carson describe?

2. On what types of fish does she report? (Name at least four.)

3. What geographical regions does she describe?

4. Which pesticides were used, in which geographical areas?

5. Why were the pesticides used? (Cite at least two cases.)

Lesson F

# Renewable Energy and the American Age of Wood

## Introduction

Renewable energy resources played a larger role in the development of industrial America than historians have generally acknowledged. Consequently, the uses of such energy sources as water power, wind power, and wood fuel have been relegated in most textbooks and classrooms to the quaint and superfluous. This lesson attempts to correct such omissions by focusing on the role played by water power and wood as fuel during the 1840s and 1850s.

The lesson focuses on a decision faced by numerous 19th-century business enterprises: whether to use steam-powered engines. The decision to switch from wood to water power in the mid-19th century was a momentous one for many businesses and industries. It entailed a number of short-term costs that had to be balanced against potential long-term benefits. Also, the switch to water power was better suited to some industries and some locations than others. Students get a clear sense of perspective and situation in technological decisions through this simulation, in which students representing different types of business activities must decide whether to use steam-powered engines or some alternative energy source.

The lesson elucidates themes 2, 3, 4, 5, and 6, addressing the following questions:

- To what extent and how do science and technology affect the social, economic, political, and cultural context in which they occur?
- To what extent are the consequences of technology intended or unintended?
- To what extent does technology affect people's standard of living and quality of life?
- What influence do different individuals and groups have on science and technology?
- Who, if anyone, controls science and technology?

**Learning Outcomes:** In small groups representing different interests and situations, students evaluate a packet of data on the pros and cons of switching from wood to steam energy in 19th-century America. They prepare written position statements on the issue as seen from the perspectives of their assigned roles and situations. After groups present their choices of action to the class, the class as a whole evaluates both the decision-making process and the choices made by each group.

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Adapted from "Teaching About the Uses of Renewable Energy Sources During the Age of Wood," by Clair W. Keller; reprinted by permission of Clair W. Keller, Professor, History/Curriculum and Instruction, Iowa State University.

## Time Required: 4 class periods

## Materials and Preparation:

- Copies of Handout F-1 for all students
- One situation card and two or three data packets for each group of students (cut the numbered items apart so they can be easily passed among group members)
- Overhead projector and overhead made from Transparency Master F-1

## Instructional Activities

Tell students that the class is going to be looking at decisions about using new technologies and some of the factors that influence such decisions. The particular technology the class will be examining involves the use of energy.

Ask students to hypothesize about the major fuel type used in the United States in the following years, with major meaning it provided the majority of energy consumed in the United States at that time—1870, 1900, 1930, and 1960. Students should jot their answers down on a piece of paper.

Next, ask students to pair up and compare their hypotheses. What reasons can they develop for the energy sources they selected?

Show the graph on Transparency Master F-1 and have students compare their hypotheses with the information presented. Which hypotheses were correct? incorrect? What information on the graph is most surprising?

Point out that in 1850 water was also an important energy source, but it had fewer uses than wood, which was used in homes, steamboats, locomotives, and early steam engines. Two factors—industrial expansion and urbanization, creating more factories without access to water or forests—led to increasing dependence on coal.

Divide the class into five groups. Distribute Handout F-1 to all students and review the assignment with the class. Distribute a different situation card to each group, as well as two or three copies of the data packet.

Allow one class period for groups to consider their situations and apply the information in the data packet to reach a decision on what they should do about switching from wood to water energy. Have each group prepare an outline identifying their decision and the arguments that support it.

Next, have each group present its situation, recommendations, and reasoning to the class. Post the following questions and have each group respond to them following their presentation:

- What factor was the most persuasive in making your decision?
- What additional information would have been helpful?
- How valid was your group's decision?

The best solution for Situations A and C would be steam power. The Savannah Saw Mill (C) is an actual mill. The Philadelphia Ironworks (A) would use steam simply because steam was an urban development. It would also employ coal as fuel. Situation B is also a real mill run by water power. It is described in John Bordon Armstrong, *Factory Under the Elms: A History of Harrisville, 1774-1869* (Cambridge, MA: MIT Press, 1969), pages 22-28. Situations D and E are representative of the small mills that continued to employ water power well into the late 19th century.

Discuss the following questions with the class:

- What factors determined the use of energy in America in the 19th century?

- Is it valid to equate steam power with industrialization? Discuss the validity of this statement: "The Industrial Revolution was based on the application of steam (with coal as the source of power) to the textile, milling, and lumber industries."
- What energy choices do manufacturers face today?
- What factors must contemporary industries consider when making energy choices?

Assign each group of students to look for information regarding factors affecting current decisions on the use of one of the following energy sources: nuclear, geothermal, wind, solar, and coal. After identifying current factors, students should consider how these factors are similar to and different from those affecting decisions in the 19th century? Each group should show the results of its research in a poster to be displayed in the classroom.

Have each student write a paragraph analyzing the strengths and weaknesses of his/her group's decision.

## Going Further

Students may wish to pursue the topic of changes in energy use over time through research papers. Local community-based studies would be especially interesting. Differential billing rates for electrical power, fuel sources for local utilities, and the transformation of wastes into fuel could be topics for research.

## References

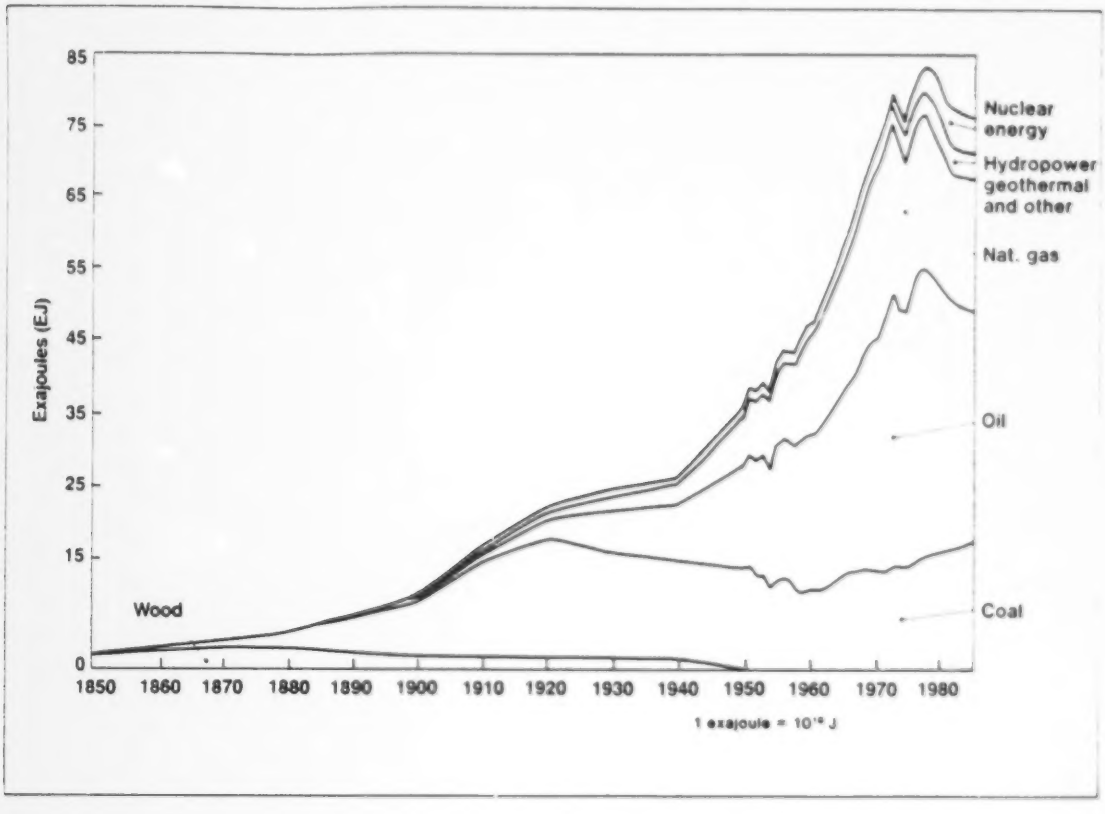
Clair W. Keller, *Involving Students in the New Social Studies* (Boston: Little Brown, 1974), pp. 41-56.

John Borden Armstrong, *Factory Under the Elms: A History of Harrisville, 1774-1869* (Cambridge, MA: MIT Press, 1969).

Carroll M. Pursell, Jr., *Early Stationary Steam Engines in America* (Washington, DC: Smithsonian Institution Press, 1969).

BEST COPY AVAILABLE

# U.S. ENERGY CONSUMPTION BY FUEL TYPE, 1850-1980

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# ASSIGNMENT SHEET

1. Your group is to represent an energy consulting firm. You make recommendations to business owners about the kind of energy they should use.
2. Each member of your consulting group is to review the material in the Data Packet. Each member is to write a discussion paper that explores the advantages and disadvantages of using steam or water power in the situation described in your Situation Card. As a conclusion, each member is to decide which would be the most advantageous power source for the business you are advising. Defend the decision with specific facts from the Data Packet.

   Due _____

3. Meet as a group and decide which power source you will recommend to the business owner. Outline your reasons on an overhead transparency as the basis for a presentation to the class.

   As you prepare your papers and your presentations, consider the following aspects of the problem:

   a. Costs: initial investment, operation and maintenance, labor, buildings

   b. Hazards: fire, flooding, droughts

   c. Environment: cleanliness, pollution

   d. Transportation needs

**SITUATION A**

You are consultants for the owner of an ironworks who needs a power source for a stamping plant. The plant will be located in Philadelphia with access to water and rail transportation. While the facility is not large, it will employ 15 workers. The owner hopes to expand the plant.

**SITUATION B**

You are consultants for an owner who wants to build a woolen mill in Harrisville, New Hampshire. It will be located near a stream that can be dammed for a millpond. The stream, although small, has potential for further dams and millponds. The factory will consist of three floors.

The owner will install three sets of machinery for manufacturing woolen cloth such as broad cloth, cassimeres, and black doeskin and has hopes of further expansion. The plant will employ 15 men and 10 women. There is no railroad, although there is talk of getting one sometime in the future. The owner will invest $18,000 in a plant that will have 600 spindles and produce 40,000 yards of cloth annually.

**SITUATION C**

You are consultants for a Southern sawmill owner who wants to build a sawmill along the Savannah River near Savannah, Georgia. The plant will employ about 50 persons and will require about $70,000 of capital investment. The plant will have three vertical saws, four circular saws, and two planning machines and will produce shingles, laths, and lumber.

**SITUATION D**

You are consultants for an owner who wants to construct a gristmill to serve local farmers in an agricultural area in Pennsylvania. The mill will employ around five persons.

**SITUATION E**

You are consultants for an owner who wants to build a sawmill in Ohio. The area is being settled rapidly. While the planned facility will be small, employing fewer than five persons, the owner hopes to expand the plant.

# BACKGROUND: WOOD AND WATER AS ENERGY

## Wood

Brooke Hindle writes in the introduction to a collection of essays entitled *America's Wooden Age*, "In this country, a technology broadly based upon wood and a society pervasively conditioned by wood persisted until the mid-19th century when wood began, selectively, to be replaced by a rising utilization of other substances."[1]

Wood was the major source of fuel, the primary building material, and a major source of chemical inputs such as potash and charcoal. As a result, the per capita consumption of wood in America increased during the first 70 years of the 19th century. America's consumption of wood was three and one-half times that of Great Britain.[2]

The availability of land was undoubtedly the strongest magnet attracting colonists to the North American shores. Closely related to the land, however, was the abundance of wood. Wood, like land, had become a scarce item in England and Europe. In 1623-1624, John Winthrop, who led the Puritan migration to Massachusetts, wrote that the scarcity of wood had driven the poor to continually chop down not only young trees and hedges but gates and bridges as well.[3]

The importance of hogs in the colonial diet resulted from the abundance of forest. Hogs could survive in the forests; sheep and cattle could not. This also meant that crop lands had to be fenced. The need to keep fences in good repair and disputes over violations led to numerous regulations, as well as the town office of fence viewer.

It should be pointed out, however, that tradition did not always give way to the forest. New England settlers continued to construct traditional English frame houses even though log cabins would have been ideal dwellings. Log cabins could have been built with the axe alone, without nails or other hardware!

Wood as a fuel for heating homes certainly influenced the growth of colonial America in many positive ways. The abundance of wood, for example, enabled colonists to live more comfortably than their counterparts in Europe. The colonists wasted a great deal of their space-heating energy by using inefficient fireplaces. When wood became increasingly expensive in urban areas because of transportation costs, the Franklin stove was developed to save fuel. Comfortably heated colonial houses contributed to the enormous population increase during the 18th century by decreasing the death rate among the colonists.

Wood as a fuel survived long after the arrival of the steam engine. The cheap and ready supply of wood along America's numerous waterways was a primary factor in the success and rapid expansion of the steamboat. A free and easily supplied source of fuel cut the cost of operating the steamboat and enabled it to become immediately competitive with other forms of transportation.

The availability of wood also influenced the spread of early railroads. Railroads ran on wooden rails and ties and spanned rivers and gulleys over wooden truss bridges. Locomotives were first made of wood rather than metal.

Wood was also a cheap fuel for railroads. When Americans imported English locomotives, they converted them from coal to wood. American-built locomotives were wood-burners. Wood served as the principal fuel used by locomotives during the 1830s and 1840s. Even naval vessels continued to use wood, rejecting a commission recommendation in 1844 urging naval vessels to shift to coal. Before coal-burning engines could become economically competitive, the inefficient methods being used to take care of coal residue had to be improved. These changes didn't come about until the mid-1850s.[4] Even then, wood-burning engines still dominated in New England and the South, where wood supplies were abundant, and in the west, where coal was scarce.[5]

## Water Power

American industry before the 1840s rested overwhelmingly upon water power. Even in 1870, according to the census of that year, 48 percent of the stationary power was provided by water power.[6] Historian Louis Hunter even questioned identifying British industrialization with steam power.

There were several reasons for the limited use of steam power in the first half of the 19th century: (1) its high initial cost; (2) unfamiliarity with its operation, maintenance, and repairs; (3) high operation costs; (4) difficulty and cost of transporting heavy equipment, such as engines and boilers; (5) the widespread, familiar low-cost alternative—water power; and (6) the steamboat boiler controversy raising the issue of boiler safety.[7] One might add also that the cleanliness, smaller space requirements, and safety of water power encouraged its use.

The importance of water power was of long standing. Like the early Americans who saw the abundant forests, the first Europeans in America also marveled at the numerous rushing rivers and streams. An abundant water power supply eased the task of providing food, shelter, and clothing and certainly contributed to the high standard of living shared by most white colonists.

The first water wheels provided power for sawmills because there were abundant supplies of wood available long before large quantities of grain were available. The first sawmill was built on the James River in 1611. The Virginia Company recruited German technicians from Hamburg to build a sawmill at the falls, thus making it possible to construct the new town of Henrico, which had three streets of well-framed houses.[8]

It is not surprising that sawmill technology, much of it imported from Europe, improved rapidly as the colonists sought to maximize the abundant resources of water and forest. Sawmills in colonial America antedated their introduction in England. Every new community established a sawmill as its first priority. The location of the sawmill often dictated the town's location.

Although water power dominated the industry, steam was utilized for sawmills as early as 1802. In that year in Philadelphia, an owner advertised that mill refuse could be used for fuel and wood ashes were excellent for fertilizer. The familiar hazards of water power—drought and flood—would be eliminated, the advertisement said. A coal-burning, steam-powered saw was reported in New York a few weeks later. Despite the claim that the sawmill would "soon make a fortune for the owner," most sawmills continued to be water-powered. In 1860, for instance, only 174 of Ohio's 437 sawmills were powered by steam.[9]

Soon after erecting a sawmill, the colonists built a gristmill, often at the same site. Although horizontal mills, which needed no gearing, had been used by the Greeks as early as 85 B.C., not all colonists could afford to build them. Many ground grain by hand. Early colonists sometimes used a simple devise called a plumping mill. This inexpensive and easily built water-powered gristmill operated like a teeter-totter with a wooden box that filled with water on one end and a pestle at the other end. "When the box was full, the weight forced the sweep downwards. The box then emptied on descent, thereby releasing the weight as it swung back again to the filling position. The counter weight, shaped like a pestle, dropped into a hardwood mortar in which the grain was placed, thus pounding the grain into a course flour."[10] Thus water power replaced the laborious task of pounding the grain by hand.

When communities built horizontal mills, they were often simple "tub wheel" mills designed to serve small communities or individual families. A stream of water was directed to a horizontal wheel, 4 or 5 feet in diameter, located beneath the mill. This turned a shaft connected to a mill stone attached directly above.[11] These horizontal mills were later replaced with the more efficient vertical wheels, which operated by directing water to either the top (the most efficient method), middle, or bottom of the wheel. Using the vertical wheel required gearing to change direction of the power, something accomplished by the Romans. Gearing also enabled the millstone to turn at greater speed than the water wheel.

Some water wheels were powered by the tide, filling a mill pond at high tide, then directing water to a wheel during low tide. They would operate for about 5 1/2 hours during each 24 hours.[12]

Some water-powered gristmills operate today, not because they are economically sound (although this may soon be the case) but because the meal, which absorbs the dampness of the mill side and has been ground finely on slow-turning old stones, produces exceptional bread.

## Summary

The Americans relied on wood and water as sources of energy well into the last half of the 19th century. These energy sources were well suited to a predominantly rural and agricultural society. The steam engine pow-

ered by coal, diesel, or gasoline is a phenomenon of the city, where forests and babbling brooks seldom exist. The high energy costs at today's market place may make wood and water power more than just a nostalgic harkening toward the past.

## Footnotes

1. Brook Hindle, "The Span of the Wooden Age," in Brook Hindle, ed., *America's Wooden Age* (Tarrytown, NJ: Sleepy Hollow Restorations, 1975), p. 3.

2. Charles Carroll, "The Forest Society of New England," in Hindle, *op. cit.*, p. 5.

3. *Energy, Engines, and Industrial Revolution* (Washington, DC: U.S. Department of Energy, August 1979), pp. 43-44, 51.

5. Edward Keuchel, "Coal Burning Locomotives: A Technological Development of the 1850's," *Pennsylvania Magazine of History and Biography*, volume 94 (October 1970), p. 486.

5. *Ibid.*, p. 485.

6. Louis Hunter, "Waterpower in the Century of the Steam Engine," in Hindle, *op. cit.*, p. 170.

7. *Ibid*, pp. 172-173.

8. Charles Peterson, "Early Lumbering: A Pictoral Essay," in Hindle, *op. cit.*, p. 66.

9. *Ibid.*, p. 76.

10. Charles Howell, "Colonial Waterwheels in the Wooden Age," in Hindle, *op. cit.*, p. 121.

11. *Ibid.*, pp. 24-30; Hunter, *Waterpower in the Century of the Steam Engine* (Charlottesville, VA: University of Virginia Press, 1960), pp. 71-81.

12. Eric Sloan, *Our Vanishing Landscape* (New York: Ballantine Books, 1974), p. 38.

**ITEM 1**

"The motives which have led to the establishment of works at small towns, eight and ten miles from the great points of shipment referred to, have been the lower price of land and the cheaper rate at which employees can live. We think it has been the experience of most manufacturers that more work has been lost by thus isolating themselves than would have many times over paid the interest on increased value of land." (Charles Wilcox, "IronWorks—Their Location, Arrangement and Construction," *Scientific American*, 15 September 1860, pp. 180-181)

**ITEM 2**

"Steampower costs proportionately very much more in small than in large quantities. Independent of this, however, small engines and boilers are much less economical than larger ones, so that the cost of fuel is much larger even at a fixed price per ton." (Charles Emery, "Cost of Steampower," *Transactions—American Society of Civil Engineers*, 1883, p. 430)

**ITEM 3**

"The waterfall is rendered available comparatively without labor, and furnishes its supplies without the intervention of human aid. The energies of the steam engine, on the contrary, can be commanded in any situation, only by the influence of the miner; and the localities much removed from sources of fuel, can only be sustained at an expense which falls heavily upon the operations to which they are subservient. That expense, it is true, is continually being diminished, and by means of the steam engine itself, in its character as a carrier; but no happy discovery, no possibility, can reduce it to the minimum at which our water-runs are maintained." (Appleton's *Dictionary of Machines*, 1852)

**ITEM 4**

"For many users waterpower was preferred for its cleanliness and the small space requirements of the equipment, and for freedom from the fire and explosion hazards of steampower, from the dirt and nuisance attending the handling and storage of fuel and ashes, and from the burden and expense of engine—and boiler room attendance." (Louis C. Hunter, *Waterpower in the Century of the Steam Engine*, 1980, p. 519)

**ITEM 5**

"Waterpower unit costs tended to increase with the size of the plant. Reverse was nearly always the case for steampower." (Louis C. Hunter, *Waterpower in the Century of the Steam Engine*, 1980, p. 519)

**ITEM 6**

"New engines developed after 1850 reduced fuel consumption from 10.0 to 2.5 pounds of coal per horsepower hour. Initial costs of steamplants were down, in part owing to the lower expense of transportation from engine builders. Maintenance and repair costs also decreased." (Louis C. Hunter, *Waterpower in the Century of the Steam Engine*, 1980, p. 487)

**ITEM 7**

"In 1854 James B. Francis, Superintendent of Lowell Industries, reported that steampower costs were three times those of water power for Lowell plants. Ten years later he reported the ratio had fallen to two to one, changing only slowly during the succeeding years. Francis declared that 'the highest rates of water power I know of are about half the cost of steam power, say $70 per horsepower per annum'." (Louis C. Hunter, *Waterpower in the Century of the Steam Engine*, 1980, p. 521)

**ITEM 8**

"In 1858 Francis wrote that the cost of water power at Lowell ranged from $15-$25 per horsepower per year, with steam power costs for coal alone in 1863 being $27.90." (Louis C. Hunter, *Waterpower in the Century of the Steam Engine*, 1980, p. 521)

**ITEM 9**

"After the Civil War—motive power was but one among many locational factors to be weighed and more commonly than not a minor one—5-10 percent of total production costs. By this time such cost advantages water power still possessed over steam power might readily be overruled by other cost and advantage considerations." (Louis C. Hunter, *Waterpower in the Century of the Steam Engine*, 1980, p. 484)

**ITEM 10**

"For a country sawmill operated by men having other duties at times, a simple torrent, dry or nearly so at times during the summer, will answer very well. The farmers' boys can get in their harvest in the dry season, get out and haul logs before the snow melts, and saw them by water power when the stream is full. Everything is of the simplest description; no labor is left idle, and the cost of the whole plant is so small that the mill may be unused for long periods without a loss worthy of consideration.

Such a state of things is not possible with the manufacturing interests of modern times. Large contracts are to be filled; large numbers of operatives are employed, skilled only in particular branches of the particular work done; hundreds of thousands of dollars of capital are invested—the mills cannot be stopped if the owners hope to compete with others doing business in a business way. If the water power fails for a season, steam is employed; and indeed, from its greater reliability, steam is used exclusively in many cases successful competition with waterpowers." (Charles E. Emery, "The Cost of Steam," *Transactions—American Society of Civil Engineers*, 1883, pp. 429-430)

**ITEM 11**

A letter from a farmer described the use of small steam engines as follows: "Three hp engine can be drawn by a single horse, 5 hp engine can be drawn by two horses, 8 hp can be used for sawing, pumping, and turning small mill stones. A 5 hp engine consumes about 1/4 cord of wood per day. Wood varies from $2.50-$3.50 per day when purchased." (*Scientific American*, 18 February 1854, p. 184)

**ITEM 12**

"Cost of Constructing a Cotton Mill with 4000 spindles. Waterpower Wheel, $1300, Steam Engine, $6000, gearing and belting, $3000; 60 hp needed to turn 4000 spindles. Building 40 x 130 feet of 3 stories high cost $12,000, employed 132 workers." (*Scientific American*, 4 August 1848, p. 365)

**ITEM 13**

Letter reports that a 38 hp engine ran 292 days, 10 hours per day, and consumed $5.77 of coal per day or $.15 hp per day. It had two boilers 30" x 30". It took 8-1/8 pounds of coal to grind one bushel of wheat into flour. Wheat costs around $1.75 per bushel. (*Scientific American*, 17 April 1858, p. 251)

**ITEM 14**

Advertisement: "Circular Saw Mill with Engine and Boiler purchased in New York, cost $1500." (*Scientific American*, 30 August 1856, p. 407)

**ITEM 15**

Advertisement: "2-1/2 hp engine cost $240, weighs 5090 lbs. and is 5 by 3 feet. Boiler is extra." (*Scientific American*, 30 August 1856, p. 407)

**ITEM 16**

By 1850 coal and wood were competitive when burned by locomotives. (Keuchel, "Coal Burning Locomotives: A Technological Development of the 1850's," *Pennsylvania Magazine of History and Biography*, October 1970, p. 486)

**ITEM 17**

Letter: "We have put into a grist mill which runs 3 pairs of stones (4 feet diameter) a 25 hp engine with a 20' by 48". It burned 1 bu. coal to grind 10 bu. of wheat or rye. Some engines consume 50 bu. coal to grind 200 bu. of grain." (*Scientific American*, 1858, p. 208)

**ITEM 18**

Advertisements for cost of Engines and Boilers:

"1 hp, $275; 3 hp, $450; 6 hp, $600; 8 hp, boiler was 16' by 30"; 30 hp without boiler, $1037; 10 hp, $1000." (*Scientific American*, 12 July 1856, p. 351)

**ITEM 19**

Cost of Operating Steam Engines

| | 5 hp | 25 hp | 100 hp |
|---|---|---|---|
| Cost, Eng./Boiler | $500 | $2000 | $9000 |
| Operating/hp/year without coal | $131 | $ 37 | $ 17 |
| Cost of coal at $4.17 per ton/hp/year | $ 43 | $ 30 | $ 19 |

(Adapted from table in Charles Emery, "Cost of Steampower," *Transactions—American Society of Civil Engineers*, 1883, p. 430)

# Lesson G

# Taking Another Look at Television

## Introduction

Two keen observers of technology and culture, Arthur C. Clarke and Neil Postman, have observed that modern technologies have become magical or mysterious to the everyday user, a fact that they propose has profound effects on people's world view. Postman argues that one effect is to cause people to "believe in the authority of our science, no matter what."

This lesson uses the comments of Clarke and Postman to engage students in consideration of television—how well we understand it, what the impact of not understanding the technology's operation might be, and the impact of the technology on individuals and our culture. In Parts A and B of the lesson, students consider how much they understand about the physical principles behind television, conducting three investigations. They also consider the ramifications of not understanding how a technology works. In Part C of the lesson, students examine questions related to HNST themes 2 and 5:

- Does television affect the behavior of people who watch it?
- Does television distort reality or create it?

**Learning Outcomes:** Students participate in several demonstrations to develop their awareness that a TV picture is composed of pixels and their understanding of persistence of vision and flicker fusion. They use persistence of vision and flicker fusion to explain why we can see TV pictures. They then conduct research and articulate opinions about the influence of TV on our culture.

## Time Required:

2-3 class periods plus out-of-class research time

## Materials and Preparation

**Part A (For each student )**

- A TV set in class or at home
- Handouts G-1 and G-2
- Magnifying lens
- Index card
- Pencil (unsharpened ones are fine)
- Tape

**Part B (For the class)**

- 1 strobe light with a range of frequency from 15-65 flashes per second
- Rulers
- Paper
- Pencils

**Part C (For each student)**

- Handout G-3

You may find it helpful to work with the school librarian or media specialist before the lesson to ensure that the library has adequate resources on television and its impact on individuals and culture. Resources that would be useful to students include the following:

Bender, David L., and Bruno Leone, *The Mass Media: Opposing Viewpoints Series* (San Diego, CA: Greenhaven Press, 1994).

Bianculli, David, *Teleliteracy: Taking Television Seriously* (New York: Continuum, 1992).

*Communication*, SIRS volume/CD-Rom (Boca Raton, FL: SIRS, updated annually).

Lubar, Steven, *Infoculture: The Smithsonian Book of Information Age Inventions* (Boston: Houghton Mifflin, 1993).

Spigel, Lynn, *Make Room for Television: Television and the Family Ideal in Postwar America* (Chicago: University of Chicago Press, 1992).

Tichi, Cecelia, *Electronic Hearth: Creating an American Television Culture* (New York: Oxford University Press, 1991).

Numerous articles in magazines and newspapers would also be useful sources of information.

## Instructional Activities

### Part A

Share the following quotations with students:

> Any sufficiently advanced technology is indistinguishable from magic—Arthur C. Clarke.
>
> The world we live in is very nearly incomprehensible to most of us...the ways of technology, like the ways of God, are awesome and mysterious—Neil Postman.

Do students agree with Clarke and Postman? Do most people regard sophisticated technologies as "magic" or "mysterious"? How might lack of understanding of how and why technologies work affect the way that people view the world? Again, use a quotation from Postman to provoke thought: "Today, we believe in the authority of our science, no matter what...There is almost no fact, whether actual or imagined, that will surprise us for very long, since we have no comprehensive and consistent picture of the world that would make the fact appear as an unacceptable contradiction."

Ask students to think specifically about television, a technology found in 98 percent of U.S. homes. How many students can explain how the television picture is created? Ask students to write down their explanations of how this occurs. Assure them that they will not be asked to turn in the explanations.

Tell students that they are going to have the opportunity to take part in several demonstrations that will help them understand the physical principles behind television.

Distribute Handout G-1. Set up TVs in your classroom or assign this activity as homework.

When the students have completed their observations and responded to the questions, check to see if they have observed that a TV picture is composed of points of light. You may want to share all or part of the background information below with students.

> Pixels make up a grid that covers the entire screen. Each pixel is composed of a material that glows for a brief moment whenever it is bombarded with electrons from an electron gun. Black-and-white TV sets contain one electron gun that fires a beam of electrons at the screen.
>
> The electron gun contains a heating element that emits a beam of electrons when it is heated. This electron beam moves quickly across the TV screen from top to bottom, one horizontal row of pixels at a time. The TV camera sends messages to the electron gun that adjust the intensity of the electron beam according to the brightness of the images. As a result, the black-and-white TV picture is composed of many glowing dots of varying shades of black and white.
>
> Color TV works in this same way, with two exceptions. First, a color TV screen is coated on the inside with pixels containing phosphor. (The word phosphor comes from the Greek word meaning "light-bearing.") Second, color TVs have three electron guns, each one responsible for illuminating a different color (red, green, and blue) on the screen.
>
> When your color TV receives signals from the TV camera, the three electron guns scan the rows of pixels. Each gun lights up only one specific color of pixels. For example, when the beam from the electron gun specific for red phosphor hits a red phosphor pixel, it produces the color red. The messages from the TV camera indicate which pixel the electron guns should activate on which part of the screen. Just as you would mix different colors of paint to produce new colors, the pixels are close enough together to blend and make different colors.

Next, focus on why a television picture composed of lots of points of color appears as a continuous picture to our eye. Distribute Handout G-2 and materials for making spinners.

After the students test their spinners, check for their understanding of the concept of persistence of vision. They should be able to tell you that the eye retains one image while it is picking up a second one. Consequently, at the right speed the bird on one side of the spinner will appear in the cage on the other side of the spinner.

## Part B

Ask the students to prepare a data table by listing a column of numbers: 15, 20, 25, etc. through 65.

Start the strobe light at 15 flashes per second. CAUTION: Tell the students never to stare directly at the strobe light. Also, it is dangerous for humans to see flashes below 15 flashes per second.

Stand to the side of the strobe light and move your arm up and down slowly. Ask the students to observe what your arm appears to be doing and record their observations in a data table.

Ask the students to continue to make these observations and record them as you increase the flash rate on the strobe light. Increase the flash rate in increments of five (20 flashes per second, 25 flashes per second, 30 flashes per second, 35, and so on) up to 60 flashes per second.

Turn off the strobe light. Ask the students to determine from their data tables the frequency at which they no longer perceive a flicker. This is called flicker-fusion frequency.

Ask the students to record the three most common flicker-fusion frequencies for the class.

After students have completed the strobe light activity, conduct a discussion with the following questions:

- If the only factor the manufacturers were considering was your flicker fusion frequency, how quickly would the electron beam have to sweep the screen for it to appear continuously lit to you?

- If a television were designed with electric signals transmitted slowly, such as 20 flashes per second, what would picture quality be like?

Following the discussion, ask students to revise or rewrite their explanations of how the television creates a picture. Also ask them to reflect, in writing, on whether they now believe that understanding how the technologies they use works might be important to them.

## Part C

Ask the students how long ago they think TV was invented. What things had to be invented to create a television? Do they think television was the work of a single inventor or a combination of contributions? After this discussion, share the following timeline with them. How does this timeline match their perspective of what happened when?

1831 Faraday demonstrates that moving a magnet through a coil of wire generates electricity. He names electrical lab equipment and concepts such as electrode, cathode, anode.

1855 Geissler develops a glass vacuum tube through which electricity can be driven. Geissler's friend, Julius Plucker, discovers that electricity passing through the glass tubes causes them to glow.

1875 Crookes tube is developed, allowing for a better study of the flow of electricity.

1876 Eugen Goldstein names the flow of energy between electrodes "cathode rays."

1879 Edison invents the electric light bulb.

1911 Millikan's work with the "cathode ray particle" becomes public knowledge.

1928 Vladimir Zworykin invents the iconoscope, a cathode ray tube with a metal sheet inside, in which the metal emitted electrons when struck by the scanning cathode ray.

1960 There are 50 million television sets in American homes.

Tell students that they are going to turn their attention to the effects of watching television. Tell them that some observers believe Americans are more prone to violence, more afraid of crime, have shorter attention spans, and are materialistic because of television. Do they agree?

Distribute Handout G-3. Ask students to work in groups and discuss the questions posed in the reading. You may want to have students write individual responses to the questions. In their small groups, students should choose an area to research. You will find some guidance on oral history and survey research in the appendix. Library resources that may be helpful to students are listed in the **Materials and Preparation** section of the lesson. Allow students several days to conduct their research and then use part of another class period for them to report their results.

Following the reports, conduct a class discussion of the information and ideas presented. To conclude the lesson, ask each student to write a script for a television editorial summarizing the most important ideas about the influence of technology they developed during this lesson. If feasible, you may want to arrange for the best editorials to be videotaped and made available to other classes.

## Going Further

If students enjoyed the strobe light activity, you can extend it by shining the strobe light on the moving blades of a fan and adjusting the rate of the strobe light. At a certain frequency, the fan blades will appear to be still.

Encourage the students to think of new pictures and make additional spinners.

## References

Asimov, I., *A Short History of Chemistry* (Westport, CT: Greenwood Press, 1965, 1979).

BSCS, *Middle School Science & Technology, Level B* (Dubuque, IA: Kendall Hunt Publishing Co. 1993).

Burke, J., *Connections* (Boston, MA: Little, Brown, and Co. 1978).

# TELEVISION OBSERVATION

In this investigation you will see what makes a TV picture.

## Materials

- A television
- A magnifying lens

## Procedure

1. Carefully observe the television picture with and without the magnifying lens.

   **CAUTION:** Prolonged exposure to an operating TV at close range may be harmful. Make any close-up observations quickly and do not linger in front of the TV screen.

2. Record your answers to these questions.
   - What does the TV screen look like when the power is on and you are getting a picture?
   - Step back from the television 3 meters. What happens to the quality of the picture as you move towards the set, beginning at a distance of about 3 meters?
   - How do your observations compare to your classmates' observations?

# CONSTRUCTING A SPINNER

## Materials

- 3-by-5-inch index card, blank
- Pencil (not to write with)
- Transparent tape

## Procedure

1. Fold the index card in half so you have a rectangle measuring 3 inches by 2-1/2 inches.
2. Turn the folded index card so the fold is up and the opening is down.
3. Draw a fish on the front of one of the folded cards and a fish bowl on the back of the same folded card, or draw a bird on the front of the folded card and a bird cage on the back of the same folded card. Make sure your drawings are centered from side to side and from top to bottom.
4. Tape the edges of the card together. Leave a slit at the bottom.
5. Stick the eraser end of the pencil into the slit at the bottom of the card. Push it up until it meets the fold and can't go in any further.
6. Center the pencil and tape the slit around the pencil closed.
7. Spin the bottom of the pencil back and forth between the palms of your hands so that you see both sides of the card flipping back and forth. Spin the pencil slowly at first and gradually increase your speed.
8. Observe what happens as you spin the pencil.
9. Trade cards with your teammate and spin each other's pictures.
10. Suggest how this experience could explain why the entire TV screen appears lit up even though each electron beam hits one pixel at a time.

# DOES TELEVISION AFFECT BEHAVIOR?

*Read through the statements on this page and decide what your opinions are. Discuss these with your teammates. Listen carefully so that you become familiar with your teammates' opinions as well as your own.*

* * * * *

Television is more than an electron beam sweeping across a coated glass screen. Its programs and content influence our everyday conversations and our perceptions of the world.

Critics of current television programs argue that violence is so common on television that we are desensitized to it, more tolerant of it, and therefore more prone to violence. Defenders of television programming argue that violence on television allows us to dispel our aggression by watching others express it.

***What is your opinion about violence on television? Is there too much, is it about right, and does it have an effect? What examples are you aware of to support your opinion?***

Elderly women are the most victimized category of individuals on television, being 30 times more likely to be caught up in a violent act than older women actually are in reality.

The evidence suggests that heavy television viewing is associated with increased perceptions of danger, even when comparing individuals who have very similar living circumstances and backgrounds. Wealthy individuals who are heavy viewers, for example, are more fearful of violence than wealthy individuals who are light viewers.

***How do the two examples above illustrate a distortion of reality?***

Most people who watch television see literally thousands of violent acts on television, many more than they will ever witness in their own lives. Why is violence so common on television?

Researcher George Gerbner states the following reasons for the common incidents of violence on television: it's attention grabbing, it fits a global market and requires no translation, it's cheap to produce, and it's easy to write quickly.

***Who sponsors most television programming in the United States? Why would they want something that grabs attention?***

People in the United States watch thousands of hours of television each year. Typically, the average number of hours watched increases each year. The incidence of violent acts in our society also increases (although sometimes in different categories). So there is a correlation in our society between increased hours of viewing and increased violence. We do not know, however, if this is a case of cause and effect. These two increases could be unrelated.

It can be difficult to discover all the factors behind a social phenomenon like the increase in violence. There may be both positive and negative effects of television that you can identify in your own community. These might be such things as an increase in the number of people using GED programs and graduating from high school, or a decrease in the number of social clubs in your community.

***Is television creating a reality that affects our society?***

***How much television do you watch each week? What are your favorite programs? What effects does television have on you, and on the environment in and around where you live?***

## Questions for Study:

In your small group, choose one of the questions below to research and report on to the class:

1. Gather information that will give you an historical perspective on television's effects. Go to the library or interview someone who lived in your community before television was available. Try to discover at least one way your community was different at that time. Verify your example by checking several sources.
2. Identify at least three things you think would be different in your life if television did not exist. Compare answers with your teammates and try to develop some generalizations about television's impact on teenagers. Survey other students to test whether your generalizations hold up for a larger group.
3. Give three examples of television's influence on our society. Use at least one example that was not mentioned in the handout. Do you think the inventors of television or people involved in early television programming anticipated these effects? Why or why not? Try to confirm or disprove your hypothesis by doing library research.

Lesson H

# Teaching About the Nature of Science

## Introduction

Students often see science as being only about answers. This lesson is designed to help students understand that science has as much to do with questions as it has to do with answers. The lesson focuses on theme 1 (science as a way of explaining the world). Variations of the activity have been used successfully with middle school through adult learners.

**Learning Outcomes:** By the end of this lesson the students will be able to recognize features about the nature of science, experience a sense of exploring the unknown, and use patterns as evidence for answering a question. They will indicate their ability by using pattern cubes to pose questions and answers, expressing frustration at not being able to turn the cube over, and describing some features of the nature of science that they experienced such as asking questions, using evidence, posing answers, constructing an argument based on evidence, using patterns as evidence, drawing reasonable inferences from a set of evidence.

**Time Required:** 1 class period

## Materials and Preparation

- 1 number cube for each group of 3
- 1 name cube for each group of 3

You will need to make one number cube and one name cube for each group of three. For older students and a shorter lesson, you can substitute one large size number cube for the smaller ones and do that part of the lesson as a large group activity.

Use the copymasters provided to create paper cubes or as a template to transfer the patterns onto wooden blocks with presstype (available at hobby stores).

If your students are likely to peek at the bottom of the cube, you may want to cover the bottom with dark paper or tape the cubes to paper plates.

## Instructional Activities

Organize the students into groups of three so that each student is sitting on a different side of the same table.

Place a number cube in the center of each group. Orient the cube so that each student can see two sides of the cube and the top. Tell the students that they may not touch the cube.

Give the students the following instructions orally, or write them on the board or an overhead transparency:

- Look at the cube and raise questions about it.
- As a team, choose one of your questions to answer. The question should be one that you can answer using patterns.
- Use the patterns, evidence, and inferences about the cube to pose an answer to your question. You may talk to each other, but you still should not touch the cube.

After a few minutes, conduct a class discussion. Ask the students what questions they generated and what answers they propose for the questions.

Ask each group how sure they are of their answer and what their evidence is. Encourage the students to be critical of their own and others work.

After the students have settled any disputes about what is on the bottom of the cube, return the cubes to a counter. Do not let the students look at the bottom. This may frustrate some because they cannot confirm their answers, but it models aspects of science such as the development of theories about things we have never observed directly (e.g., center of the earth, molecular models).

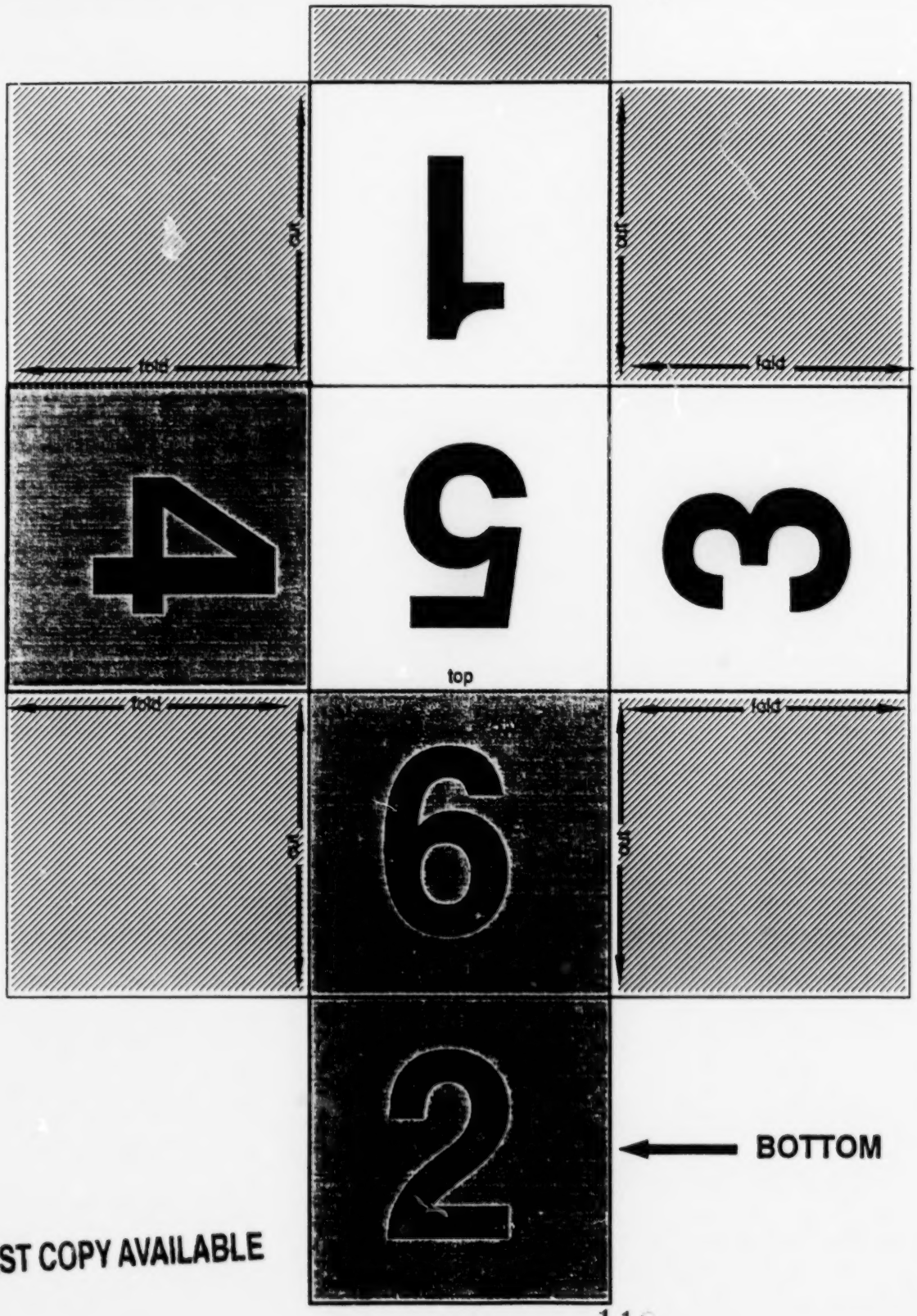
Repeat the above steps with the name cube. This will take longer because the patterns are more complex.

As the groups wind down, encourage them to draw a picture of what the bottom of the cube looks like.

When all the groups are finished, conduct another discussion around the following questions:

- What was the question your group tried to answer?
- What patterns helped you answer that question?
- What is your proposed answer?
- What evidence do you have to support your answer?
- What inferences did you make?
- How certain are you of your answer?

Again, return the cubes to a counter without letting the students turn them over. Discuss what it feels like to not be able to verify an answer they are fairly sure of. Ask how they think scientists feel when they cannot find out for sure.

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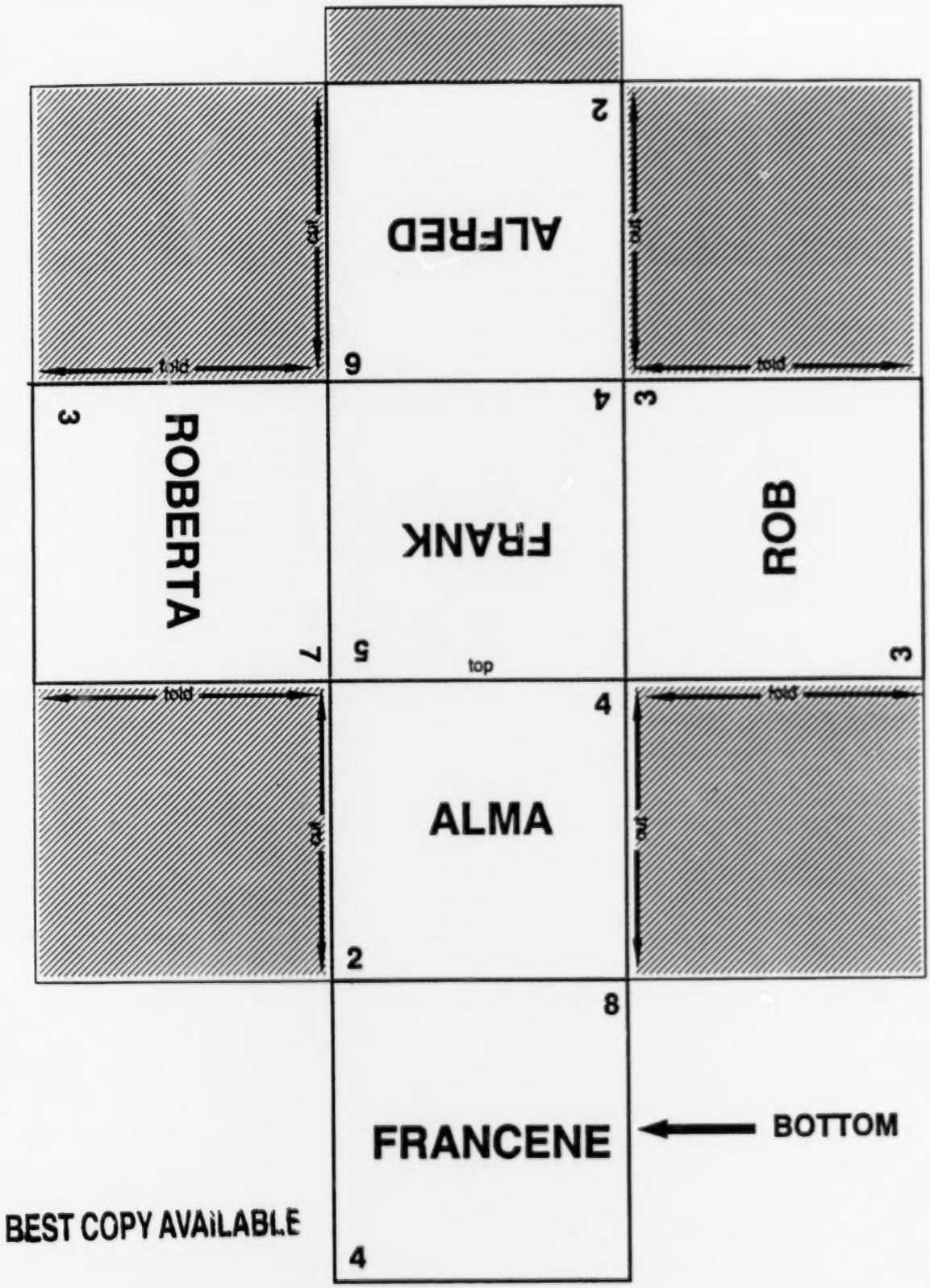


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# Lesson I

# Technology Learning Stations

## Introduction

This activity explores the impact of culture on the development and use of technology, focusing on HNST themes 2 and 4. Theme 2 describes technology as a way of adapting to the world; theme 4 states that the social, cultural, and environmental contexts within which they occur influence the conduct and content of science and technology. This lesson uses the engage and explore steps of the constructivist teaching model and could function as the initial lesson in a larger classroom examination of themes 2 and 4. In this activity, students define and provide examples of technology and culture, then explore their interrelationships by examining artifacts—technologies from several cultures. Through the activity, students address these questions:

1. What is technology?

2. What influence does culture have on the development and use of technology?

**Learning Outcomes:** Students define and provide examples of technology and of components of culture. They then examine technologies from multiple cultures, hypothesizing about the cultures that produced given technologies. Based on these experiences, they develop an understanding of the relationships between technology and culture.

**Time Required:** 1 class period

**Materials and Preparation:** Prior to this activity, collect an assortment of technological artifacts from various cultures representing different time periods, low and high technology, and a range of uses. You might solicit items from other teachers, district artifact kits, friends who have traveled extensively, etc. For a class of 30 students, 12 to 15 artifacts should be sufficient. Examples of artifacts might include:

- Motion-detecting light
- TV remote control device
- Kenyan coconut cutter
- Japanese kids' training chopsticks
- Child-proof pain reliever bottle
- Wooden herb grinder
- Silly putty
- Cappucino maker

- Freeze-dried food
- Sony Watchman/Walkman
- Gore-tex mittens or jacket
- Abacus
- Wooden spindle

Arrange the artifacts on tables around the classroom. Number each artifact, but do not otherwise label them.

## Instructional Activities

Begin the lesson by writing the word *technology* on the overhead or chalkboard. Ask students to define technology, then to brainstorm a list of items that are technologies. (A common definition of technology is "applied science." Students may offer this definition; let students know that many technologies have been developed prior to a scientific explanation of their use and function. The wheel is an example of such a technology.) Guide students to an understanding that technologies are developed by humans as a way of adapting to our world and are intended to solve a problem.

Write the word *culture* on the overhead or chalkboard. Ask students what is meant by the term; then, as a large group, brainstorm the components of culture. Record student ideas. (Culture includes all the patterns of behavior found in human groups. It includes all the ways humans have found to live with each other and in the natural environment. Culture is made up of beliefs, social forms, and customs, as well as physical items, such as food, clothing, shelter, and tools.)

Tell students that they will be examining a variety of technological artifacts, first as individuals and then as part of a group. Direct students to visit each station and examine each artifact. For each item, have students attempt to answer the following questions:

- What is it?
- What problem does/did it solve?
- What is it made of?

After students have examined each artifact, have them form small groups to compare their answers to the questions above.

Ask students to report their ideas and, as a class, try to arrive at agreed-on answers. If students have not already figured out what each item is, tell them.

Distribute one of the technology artifacts to each small group. Referring to the student-generated list of components of culture, ask students to think about every piece/component of culture that went into the creation of this item. Ask students to form a hypothesis about the culture/society that produced this artifact. Have them describe the culture. What does/did that culture value? How does the artifact reflect this value?

Ask each group to present their artifact and to share their hypotheses. After each presentation, ask the class if they can think of alternative hypotheses about the culture that produced the artifact.

To conclude the activity, direct each group to generate a statement about the relationship between culture and technology. How does culture affect the development of technology? Ask the groups to share their statements.

## Going Further

To further develop Theme 4, students could do research to explore various social and cultural impacts on the development, selection, and use of technology by different societies over time. Two books that may be helpful to such research include Arnold Pacey, *Technology in World Civilization* (Cambridge, MA: MIT Press, 1990), and George Basalla, *The Evolution of Technology* (New York: Cambridge University Press, 1988). Both books provide ample examples of the interaction of culture with technological invention and use in Asia, especially China, as well as in the West.

# Lesson J

# Thinking about Bioethics

## Introduction

The past 25 years have seen incredible advances in our understanding of genetics. These advances have generated an array of ethical issues, one of which—how the results of genetic screening should be used—is the focus for this lesson. The lesson provides a framework for examination of ethical issues in terms of *goals*, *rights*, and *duties*. The lesson's HNST focus is theme 3 (science and technology are activities that involve human values), helping students recognize value conflicts that underlie ethical issues related to genetic screening.

**Learning Outcomes:** In this lesson, students discuss ethical issues as matters of goals, rights, and duties. They then apply the notions of goals, rights, and duties to the analysis of a case study in genetic counseling.

**Time Required:** 1 class period

## Materials and Preparation:

- Handouts J-1 and J-2

## Instructional Activities

Begin the lesson by writing the word *bioethics* on the chalkboard. Point out the two parts of the word and encourage students to develop their own definitions for the term. Next, lead a brainstorming session in which students generate a list of very general issues that might fall within their definition of *bioethics* (e.g., euthanasia, creation of new life forms through genetic engineering, genetic screening, use of fetal tissue in research).

Tell students that they are going to focus on one issue that concerns bioethicists—genetic screening. They will use a framework of goals, rights, and duties to analyze the issue. Distribute Handout J-1 and allow time for students to read it. Briefly answer any questions students have about the framework.

Next, have students read Handout J-2, which presents the case they will be analyzing.

Organize the class into teams of three students. Ask each team to select a recorder. The recorder should divide a sheet of paper into three columns, labeled "Goals," "Rights," and "Duties."

Ask the teams to list the goals, rights, and duties that might be perceived by anyone involved in the case study situation.

The category system should prove relatively easy for students to use, and they may quickly find a number of areas of potential conflict. A full list of possible responses is too long to give here. The students might find, for

example, that the counselor has a number of alternatives, including persuasion, referral of Stuart to another counselor, waiting for Stuart to change his mind, and others. For the sake of argument, let's just consider the most extreme and opposite choices: to tell or not to tell. Going against Stuart's wishes can be justified on several grounds—such as the *rights* of the others to know about their own health status, the *goal* of health promotion for all these individuals, and, thus, the counselor's *duty* to pursue that goal. On the other extreme is the counselor's *duty* to maintain confidentiality and respect Stuart's wishes. This *duty* may be seen as derived from Stuart's *right* to determine how he will interact with other family members. In keeping silent, the counselor would see the *goal* of respect for persons, in this case Stuart, as of a higher value than the goal of promoting health in the possible future offspring that Stuart or other members of his family might have.

To expand this type of analysis further, ask the students to consider what kinds of ethical arguments might arise if Stuart's fiancee called and asked the counselor about the results of Stuart's screening: Should the counselor divulge the results to her? Suppose the situation were even more complicated: What if the fiancee indicated that she herself is a carrier? What should the counselor do then? Why?

By now, the students should recognize that the identification of goals, rights, and duties doesn't solve the problem. Ask them to identify the value of using this framework in analyzing the issue.

You may want to point out that this breakdown can make the variety of choices clearer, and it can break one big decision down into several smaller ones. Sometimes, the smaller decisions can be resolved one at a time, making the situation more manageable. For example, in the case of Stuart Greendale, we can identify at least three sets of rights that may be in conflict. Stuart has rights, his fiancee has rights, and the child they may have someday will have rights, too. One can imagine landmark court cases in which decisions might go against or in favor of any one of these three. Depending upon the number and nature of such cases, society might eventually come to accept the view that one of these three has rights that predominate over those of the other two. Once the question of rights had some history of debate and decision, a trend might emerge that would make the decision "to tell or not to tell" a bit easier in the future.

Nevertheless, we are not likely to see some theory of morality arising that will settle these questions once and for all, at least not in the near future. Students of ethics are still some way from a single unifying theory that will serve philosophers as the theory of relativity serves astrophysicists. As Dworkin has noted: "In many ways it is easier to agree on the nature of distant galaxies than it is to agree about the proper way to treat one's neighbors."

After the groups have completed their work, convene the entire class for the reports of each team and for discussion of the case study. Use the following questions and notes to organize the discussion:

- Discuss the case in terms of the goals, rights, and duties that may be involved. Ask a volunteer to record goals, rights, and duties on the chalkboard.
- How does this analysis of goals, rights, or duties influence such questions as "What do you think the counselor should do?"
  [Individual students might find themselves more influenced by one of the three categories than by the other two. This tends to be true both in personal opinion and in more formal presentations of ethical arguments.]
- In the case of Stuart Greendale, what do you think the counselor will do? Why?

After the students have discussed their ideas, provide the following information for discussion:

What should the counselor do? There is a clear moral dilemma in this situation. One of the central ethical tenets of medicine is nonmaleficence—*primum non nocere*—"above all, do no harm." Clearly, there is a potential for harm to any offspring that Stuart and his wife might have. There is also potential for harm to the offspring of Stuart's sister and brother, if they are carriers.

The obligation of health professionals to respect patient confidentiality, however, is as long standing an ethical tenet as is nonmaleficence. In 1983, the President's Commission for the Study of Ethical Problems in medicine and Biomedical and Behavioral Research concluded as follows:

It might seem that a genetic counselor ought never to disclose information against the wishes of a client, because the counselor's professional obligation is to the client, not to others. Both the law and morality recognize, however, that a professional's primary obligation is in some circumstances subsumed by the need to prevent harm to others. Perhaps the clearest medical application of this principle is that of health providers' obligation to report communicable diseases. Genetic disease is not strictly analogous to communicable diseases, although it might be argued that the major difference is that transmission is "horizontal" in the one case and "vertical" in the other. Yet the relevant similarity is that in both cases the duty to prevent harm to others may in some instances place limits on the professional's duty of confidentiality.

A professional's ethical duty of confidentiality to an immediate patient or client can be overridden only if several conditions are satisfied: (1) reasonable efforts to elicit voluntary consent to disclosures have failed; (2) there is a high probability both that harm will occur if the information is withheld and that the disclosed information will actually be used to avert harm; (3) the harm that identifiable individuals would suffer would be serious; and (4) appropriate precautions are taken to ensure that only the genetic information needed for diagnosis and/or treatment of the disease in question is disclosed. The individual's family history (pedigree) should be carefully analyzed to identify accurately any relatives at increased risk so that information is presented only to the appropriate individuals, and anonymity should be preserved wherever possible. Since the decision to breach professional confidentiality is such a weighty one, it may also be advisable to seek review by an appropriate third party.

With improved public education about genetics, however, and appropriate genetic counseling in individual cases, it is hoped that involuntary disclosure will be infrequent. When a person understands that there is nothing shameful about a genetic disease or trait and that the information may be invaluable to relatives, either for their own health care or for their decisions about childbearing, willingness (or even eagerness) to share the information with relatives should increase.

Discuss these differing perspectives with the students, emphasizing the ethical positions inherent in each perspective.

## References

C. R. Barman and J. R. Hendrix, "Exploring Bioethical Issues: An Instructional Model," *The American Biology Teacher* 45, no. 1 (1983), p. 23.

Dworkin, Gerald, "Analyzing Ethical Problems," from *Hard Choices*, A Magazine on the Ethics of Sickness and Health. Office of Radio and Television Learning, Boston, Massachusetts.

National Academy of Sciences, *Genetic Screening: Programs, Principles, and Research* (Washington, DC: National Academy of Sciences, 1975).

President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research, *Screening and Counseling for Genetic Conditions* (Washington, DC: U.S. Government Printing Office, 1983).

## Going Further

Students might look in the newspaper for cases that involve issues related to some of the other areas they brainstormed in the beginning of the lesson. Would the goals, duties, rights framework be helpful in analyzing these issues? Encourage students to make posters showing their analysis of the issues they read about in the news.

# THINKING ABOUT BIOETHICS

## Goals

One can judge the morality of an act by looking at what it intends to accomplish. We can ask ourselves about the objectives or outcomes. We can focus on consequences. In this pattern of thought, then, a "good" outcome may be judged morally correct regardless of how the goal was achieved. This may be termed the "any means to an end" idea.

Consider some examples. Suppose we could agree that a father caring for his children is a morally desirable goal, and that a father should take any and all necessary steps to assure that his children survive. We might then conclude that stealing food from a neighbor to feed his starving children would be a morally justified choice. We might be tempted to qualify this judgment with such statements as "if there were no other way," but in offering such exceptions we would be calling upon other moral ideas such as the duty to be honest.

Another example may help further define moral arguments that rely on goals. A physician may view his or her primary mission as the preservation of life. Life, by this view, is to be sustained as long as possible by any means possible. In this goal-oriented view, then, a physician might refuse to disconnect a respirator on a comatose patient whose vital signs were being maintained only by the machine. The physician might take such action against the wishes of the patient's family or even against the previously expressed wishes of the patient. In the physician's view, then, going against the rights of the patient would be justified by the *goal* of preservation of life.

## Rights

Moral arguments that involve the notion of rights are familiar to us in many areas besides genetics, health, or medicine. One is said to have a *right* if one is entitled to a certain kind of treatment, no matter what the consequences. The founders of our country spoke of the inalienable rights of life, liberty, and the pursuit of happiness. They claimed that one could expect these things regardless of the situation or the outcomes—just by virtue of being an individual human being. Thus, we have derived as part of our political heritage the belief that each person has a right of free speech, a right to vote, or a right to own property.

It is not hard to think of situations in genetics and medicine where one might use arguments about rights to support a particular course of action. For example, consider the matter of informed consent. Informed consent—the full disclosure of all relevant information so a patient can accept or refuse some treatment—rests on the belief that a person has a right to know all there is to know and to make up his or her own mind freely. In this view, no treatment can be given unless the person understands the procedure and chooses to undergo it.

This right to know and choose is widely acknowledged among physicians, and informed consent is routinely practiced. Imagine, however, a physician who feels that some treatment will save a patient's life. But the physician knows also that this patient will refuse if all the possible consequences of the treatment are spelled out. How much information should the doctor share? Would the physician be justified in violating the patient's *rights* because the *goal* is the saving of a life?

You can readily see how goals and rights can come into conflict. What situations can you imagine in which the rights of different individuals are in conflict? How are rights gained or lost? Can rights be limited by authority or by mutual agreement?

## Duties

The duty or obligation to act in a certain way is often cited in ethical argument. We typically think of having a duty to tell the truth, keep a promise, or help a friend. Usually, duties are justified by suggesting that the act will achieve some worthy goal, or that the act is required because of someone's right. Thus, duties may be derived from goals or rights and may be in conflict with either goals or rights or even other duties.

A defending lawyer's relationship with the accused lawbreaker involves duties that are derived from goals and rights. It is the *right* of the accused to have legal representation, regardless of innocence or guilt. It is the attorney's *duty* to seek the goal of acquittal, without consideration of the consequences for either the defendant or for society.

The logic of duties can become very complicated. Suppose a dying man asks a physician not to take any extraordinary steps to prolong his life. Does the doctor have a *duty* to comply with the man's wishes because of the patient's *right* to die? Or does the physician have a *duty* to ignore the man's wishes because of the goal of the preservation of life?

# A BRIEF CASE STUDY IN BIOETHICS

Stuart Greendale is a 22-year-old Jewish male who lives in Boston, Massachusetts. Stuart has a 24-year-old brother and a 19-year-old sister. Stuart's family traces its lineage to Eastern Europe, and he is aware that the family is at increased risk for carrying the gene for Tay-Sach's disease (TSD). This fatal disease of early childhood is inherited as an autosomal recessive. This means that if both parents are carriers of Tay Sachs, each of their offspring would have a 25 percent chance of developing the disease. As many as 1 in 30 individuals of Ashkenazic descent may be carriers. The disease is associated with progressive mental deterioration and blindness. Death from pneumonia or a lung infection usually occurs around three years of age.

Stuart participates in a voluntary screening program for TSD at his synagogue; the test reveals that he is heterozygous—a carrier. When the genetic counselor informs Stuart of his carrier status, Stuart reveals that he is engaged to a 23-year-old woman who also is of Ashkenazic Jewish background.

The counselor suggests that Stuart discuss his carrier status with his fiancee and with his family. Stuart says he will not reveal the information to anyone, and he forbids the counselor to disclose the information.

CHAPTER 5

# Resources for Teaching About the History and Nature of Science and Technology

## Introduction

This chapter provides sources of information and materials for teachers who plan to include the history and nature of science and technology in their courses. Although we discovered that appropriate materials can be challenging to find and obtain, we have assembled a variety of sources for both middle school and high school science and social studies teachers.

The materials we cite clearly address one or more of the themes described in Chapter 2, present accurate content, and are readily accessible. We also looked for materials that made connections between science, technology, and students' own lives, although not all of the materials listed meet this criterion. Finally, we made an effort to find materials organized in a constructivist manner; while this standard was difficult to achieve, we were successful in finding materials—including many employing active learning strategies—that can easily be adapted to meet the needs of the constructivist teacher.

The chapter is divided into two major sections: **Teaching Resources** and **Interesting Readings for Teachers.** The **Teaching Resources** section includes a variety of materials for use with students. The section is divided into the following subsections: (1) Print Curriculum Materials (including instructional units, books, and posters), (2), Software, (3) Instructional Videos, and (4) Commercial Films.

We begin each subsection with a discussion of how to use the category of materials discussed in that section. We then provide an alphabetical listing of resources. For each item, we provide a description and source information. Because prices change so quickly, we have not included specific price information. Instead, we indicate the general price range using the following key:

$—Inexpensive ($1.00-$25.00)
$$—Reasonable ($25.01-$75.00)
$$$—Somewhat Expensive ($75.01-$155.00)
$$$$—Expensive ($155.01+)

We indicate the themes (by number) that each resource emphasizes at the end of its description. The themes are coded as follows:

1. Science is a way of explaining the world.

2. Technology is a way of adapting to the world.

3. Science and technology are activities that involve human values.

4. The social, cultural, and environmental contexts within which they occur influence the conduct and content of science and technology.

5. Science and technology influence the social, cultural, and environmental contexts within which they occur.

6. Science and technology have reciprocal effects and their relationships vary from time to time and place to place.

Many of the resources listed are suitable for use in several traditional science and social studies courses, as well as in interdisciplinary units or courses. To encour-

age you to think broadly about potential materials, we have not organized the materials according to those traditional course titles. For your convenience, however, Table 5.1 correlates common course titles and important areas of study (e.g., multicultural studies) with the resources annotated in this chapter.

The **Interesting Readings for Teachers** section contains books and journals selected for teachers to read in order to increase their own knowledge of HNST. The readings are organized into the following subsections: History and Nature of Science, History and Nature of Technology, and Journals and Newsletters.

These listings are not comprehensive. We have selected some classics in the field, plus some new and exciting resources, all with the intent of encouraging you to deepen your understanding of this content area.

Although we are aware that the number of on-line resources is increasing at an incredible pace, we have not listed such resources in this chapter. Because of the rapid changes, any list would be instantly outdated. *NSTA Reports* regularly includes a roundup of Internet resources. We recommend NSTA's publications as a starting point for learning more about on-line resources.

## Table 5.1
## CORRELATION OF TEACHING RESOURCES WITH COMMON COURSE TITLES AND TOPICS

| | Print Curriculum Materials and Books* | Software* | Instructional Videos & Commercial Films* |
|---|---|---|---|
| Biology | 3, 9, 12, 17, 23, 24, 31, 34, 84, 107 | 38, 39, 40, 44 | 50, 53, 54, 59, 60, 65, 70, 71, 75, 79 |
| Chemistry | 14, 24, 88, 99 | 44 | 47, 72 |
| Physics | 4, 13, 14, 15, 17, 97, 98, 99 | 36 | 46, 48, 63, 67, 68 |
| Physical Science | 1, 11, 15, 16, 18, 29, 32, 34, 97 | 37, 42, 44 | 46, 48, 58, 66, 67, 68, 73, 78 |
| Life Science | 14, 16, 23, 24, 25, 35, 107 | 38, 39, 44 | 54, 59, 70, 75, 79 |
| Environmental/ Earth Science | 2, 6, 9, 12, 16, 21, 23, 24, 25, 30 | 38, 41, 44, 45 | 49, 50, 51, 52, 54, 57, 60, 66 |
| U.S. History | 1, 2, 5, 6, 8, 11, 15, 18, 26, 27, 32, 33, 34, 79, 97, 98, 99, 109 | 36, 37, 43 | 54, 55, 56, 57, 60, 61, 62, 63, 64, 68, 71, 73, 76, 78 |
| Geography | 6, 9, 17, 27, 30 | 38, 39, 45 | 51, 52, 60, 69, 70, 75 |
| World History | 6, 7, 10, 16, 20, 26, 27, 29, 84 | 36, 37, 41, 42, 44, 45 | 49, 50, 54, 57, 58 |
| Civics/Government | 3, 9, 17, 22, 23, 24, 26, 27, 30, 31 | 38 | 53, 60, 65, 79 |
| Economics | 5, 27, 99 | 40 | 56, 61, 62 |
| Current Events | 3, 9, 17, 22, 23, 24, 27, 28,30, 31, 104 | 38 | 53, 59, 63, 65, 67, 72, 74, 75, 76, 77, 79 |
| Women in Science | 19 | | 49, 70 |
| Multicultural Studies | 20, 35 | 37, 41 | 57 |

*Numbers refer to entry numbers in **Teaching Resources** and **Interesting Readings**... sections. Books and newsletters from the **Interesting Readings for Teachers** section are listed here if students could use portions of the materials directly.

# Teaching Resources: Curriculum Materials

The materials annotated in this section are generally supplemental in nature. They include posters, magazines for students, collections of lesson plans, complete instructional units, and packets of source material. Some will take only one or two class periods to complete, whereas a few provide instruction for up to a semester.

Because of the wide range of formats represented, the materials can be used in a variety of ways. For example, posters can be used to stimulate student thinking and writing, as the centerpiece of a teacher-created bulletin board, or as models for students' own products. Projects described in magazines for students can serve as the basis for learning centers completed individually or by small groups. We encourage teachers to be creative in their use of these materials and to share their ideas with us so we can disseminate them to other teachers interested in HNST.

1. *American Inventions* (1991). $

**Description:** Each laminated poster in this set of five shows inventions from a particular period in U.S. history; the years from 1750 to 1990 are covered. For each invention, an illustration and brief description are provided. The inventions shown are wide-ranging; for example, the poster for the pre-Civil War period shows the safety pin, the iron frame for the grand piano, a safety mechanism for elevators, the sewing machine, the vacuum cleaner, printing telegraph, glass jars, and vulcanized rubber. (Themes 2, 5)

**Source:** Perfection Learning Corporation, Logan, IA 51546; (800)831-4190.

2. *Art to Zoo* (quarterly). Free.

**Description:** This free newsletter from the Smithsonian provides lesson plans and background material on historical and other topics, many of interest to HNST teachers. For example, recent issues have focused on how paleontologists do their work, the effects of the Industrial Revolution on society, and the skill of constructing a historical narrative. Lesson plans are suitable for grades 3-8 and are provided in Spanish and English. (Themes 1-5)

**Source:** Office of Elementary and Secondary Education, Smithsonian Institution, Washington, DC 20560; (202)357-2404.

3. *Biotechnology: Principles and Issues*, by David E. Newton (1991). $$

**Description:** Posters and worksheets are used to introduce biotechnology to high school students. The packet is not intended to be a comprehensive introduction, but rather to acquaint students with scientific, technical, and ethical issues surrounding research in this area. (Theme 3)

**Source:** J. Weston Walch, Box 658, Portland, ME 04104-0658; (800)341-6094.

4. *Brief History of Time Teaching Package, A* (1993). $$

**Description:** Unique to this package is *The Physics of the Stars: A Study Guide*, which provides activities to do in conjunction with viewing the film, *A Brief History of Time*. The film, which is partly a biography of Stephen Hawking and partly a reflection on his work on the origin of the universe, is also included in the packet, as are a movie poster and *Stephen Hawking's A Brief History of Time: A Reader's Companion*. (Theme 1)

**Source:** Triton Pictures, 9000 Sunset Boulevard, Suite 504, Los Angeles, CA 90069; (800)433-9833.

5. *Carbons to Computers: The Changing American Office*, by Michelle Smith (1989). Free.

**Description:** This history unit looks at the impact of changing technologies on the workplace, specifically the office. The unit involves both in-class activities and independent research projects that involve collecting data by interviewing office workers and observing offices. The unit contains a teacher's guide, essay booklet, and study prints. (Theme 5)

**Source:** Office of Elementary and Secondary Education, Smithsonian Institution, Washington, DC 20560; (202)357-2404.

6. *The Changing City* and *The Changing Countryside*, by Jorg Muller (1977). $

**Description:** Each of these titles is a portfolio of several poster-sized paintings of one scene, showing the effects of encroaching development from the 1950s through the 1970s. One set shows an urban scene, the other a rural scene. The posters are an effective way to

open a lesson or unit on the effects of technology on society and the environment. (Theme 5)

**Source:** Simon & Schuster, 200 Old Tappan Road, Old Tappan, NJ 07675-7095; (800)223-2336.

7. *Classical Ingenuity: The Legacy of the Greek and Roman Architects, Artists, and Inventors,* by Charles F. Baker III and Rosalie F. Baker (1993). $

**Description:** This paperback book provides readings suitable for middle school students on the following topics: the seven wonders of the ancient world, the classical temple, ancient artists and their crafts, Roman engineering, and inventions of the classic Greeks. For each set of readings, the authors also provide a project (e.g., making a sundial), several puzzles, topics for comparison with contemporary architecture and engineering, writing assignments, research activities, and topics for debate. (Themes 2, 4, 5)

**Source:** Cobblestone Publishing, 7 School Street, Peterborough, NH 03458; (603)924-7209.

8. *Cobblestone* (10 issues annually). $

**Description:** Each issue of this history magazine for upper elementary and middle school students contains articles and activities on a theme. For example, the February 1992 issue on "African-American Inventors" included an article on a 1900 Patent Office survey to gather information about black inventors, profiles of several inventors, an article on the African-American exhibit at the 1895 International Exposition in Atlanta, directions for making a traffic signal, a play for students to enact, and a list of related books and exhibits. Back issues and theme packs (sets of magazines related to such large topics as "Science and Technology") are available. (Themes 1-5)

**Source:** Cobblestone Publishing, 7 School Street, Peterborough, NH 03458-1454; (603)924-7209.

9. *Creative Role-Playing Exercises in Science and Technology* (1989-1990). $

**Description:** This series includes three role plays developed to help prepare high school students for participation as informed citizens in the making and analysis of public policy related to science and technology. Each activity focuses on a science-related issue and integrates the presentation of scientific and societal data with a risk assessment and decision-making exercise. Topics are AIDS and drug research, storage of spent nuclear fuel, and waste disposal. (Themes 3, 4, 5)

**Source:** Social Science Education Consortium, P.O. Box 21270, Boulder, CO 80308-4270; (303)492-8154.

10. *Crowning the Cathedral of Florence: Brunelleschi Builds His Dome: A Unit of Study for Grades 7-9,* by Linda Symcox (1991). $

**Description:** This unit focuses on the technological, artistic, and community achievement represented by the cathedral at Florence. The unit outlines how diverse factors, including the guild government of Florence, the plague, and the "genius" of Brunelleschi contributed to the building of a cathedral that marked a major change in architectural styles as well as a significant technological achievement. Many primary sources are used. (Themes 2, 3, 4)

**Source:** National Center for History in the Schools, University of California, Los Angeles, Moore Hall 231, 405 Hilgard Avenue, Los Angeles, CA 90024-1521; (310)825-4702.

11. *Early Industrialization of America* (1977). $

**Description:** Each Jackdaw publication is a portfolio containing primary source documents related to its topic. This packet on early industrialization includes such items as a letter from Samuel Slater to his employer dated August 19, 1795, a 1794 design for a fully automated grist mill, two pages from a company's wage book of 1827, a broadside urging that the Erie Canal be made larger, and maps showing transportation routes in 1840 and 1860. We also recommend such other Jackdaw Publications as *Computers, James Watt and Steam Power,* and *Columbus and the Age of Explorers.* (Themes 2, 3, 4, 5)

**Source:** Jackdaw Publications. Box 503, Amawalk, NY 10501; (914)962-6911.

12. *Evolution: Inquiries into Biology and Earth Science* (1992). $$$ ($$$$ with videodisc)

**Description:** This curriculum package developed by BSCS introduces high school students to some of the basic concepts of evolution. It employs the interaction of earth science and biology to explain the evolution of life and the planet. By actively participating in investigations, students become familiar with ways in which scientists ask questions and search for answers. The package consists of an interactive videodisc; a student book for earth science, *Evolution: Inquiries into Earth Science;* a student book for biology, *Evolution: Inquiries into Biology;* and an annotated teacher's guide. The 21 activities included address a wide range of evolution-

ary topics that can be integrated into high school science curricula throughout the year. (Theme 1)

**Source:** Videodiscovery, 1700 Westlake Ave., Suite 600, Seattle, WA 98109-3012; (800)548-3472.

13. *Great Experiments in Physics: Firsthand Accounts from Galileo to Einstein,* by Morris H. Shamos (1987). $

**Description:** This book's purpose is to help physics students and teachers recognize the most significant ideas in physics. In the introduction, Shamos describes his concern about overly cluttered texts. He has selected 20 experiments and provided the historical context and scientific significance of each, followed by the text of an original experiment. All works originally not in English have been translated. Each experiment is carefully footnoted for clarity. Because there are few diagrams, however, most high school physics students would need to pursue these as a classroom, rather than individual, activity. Part of the brilliance of these works lies in the fact that authors such as Galileo and Joule wrote in conversational form and presented the arguments against their works as well as those that promote their theories. (Theme 1)

**Source:** Dover Publications, Inc., 31 East 2nd Street, Mineola, NY 11501; (516)294-7000.

14. *Historical Science Experiments on File: Experiments, Demonstrations, and Projects for School and Home* (1993). $$$

**Description:** This three-ring binder presents reproducible masters that include 51 biographies of scientists, plus directions for recreating 65 historical science experiments. The experiments are divided into such categories as "mechanics and general physics," "chemistry," "life science," and "light and sound." For each experiment, a brief background section explains the experiment's significance in the history of science. (Themes 1, 4, 6)

**Source:** Facts on File, 460 Park Avenue South, New York, NY 10016; (800)322-8755.

15. *History of Science and Technology in Industrial America, The: Teacher's Guide,* edited by Matthew T. Downey, 1989. $

**Description:** This notebook contains four teacher-developed units on inventors and inventions, each with five to eight lessons. Titles of the units, which are suitable for middle school students, are "Fulton, Livingston, and the Steamboat"; "Samuel F. B. Morse and the Telegraph"; "Thomas Alva Edison and the Electric Light"; and "The Wright Brothers and the Airplane." The units provide some insights on the nature of invention, emphasizing that one person rarely invents something on his/her own, but instead builds on the work of others. (Themes 2, 5, 6)

**Source:** The Clio Project, School of Education, Tolman Hall 5507, University of California-Berkeley, Berkeley, CA 94720; (510)642-4793.

16. *I Have a Story about That: Historical Vignettes to Enhance the Teaching of the Nature of Science,* by L. E. Roach (1992). $

**Description:** This book contains approximately 20 short stories to be read aloud to upper elementary or middle school students. Each vignette is written to include a point of conflict for the scientist described, and questions to ask the students. After discussion, students are then told how the scientist resolved the conflict in her or his life or research. (Themes 1, 3)

**Source:** Roach Publishing Company, Route 4, Box 376, Natchitoches, LA 71458; no phone number available.

17. *Ideas in Conflict.* $/book; $$$$/set of 28

**Description:** Each book in this series presents pro and con views from experts on various issues related to a topic. Sample topics of interest to HNST teachers include ecocide and genocide in the vanishing forest, reproductive technologies, nuclear waste, and genetic engineering. Instructional material on such skills as detecting cultural bias and analyzing editorial cartoons is provided to help students analyze the material presented. (Themes 3, 4, 5)

**Source:** GEM Publications, 411 Mallalieu Drive, Hudson, WI 54016; (715)386-7113.

18. *Industrial Revolution of the Nineteenth Century,* by Jennifer Moreland (1992). $

**Description:** This resource provides research activities for elementary and middle school students to complete in a self-directed study of the Industrial Revolution. While it is unlikely that students would gain a coherent understanding of the period by working through these activities on their own, teachers may find some useful ideas in this resource that they can use to supplement their usual unit on the Industrial Revolution. (Themes 2, 5)

**Source:** Zephyr Press, Box 66006, Tucson, AZ 85728-6006; (602)322-5090.

19. *Inventive Women* (1993). $

**Description:** *Inventive Women* is a set of 11 posters, each showing one woman inventor, information about her and her invention, and a list of other women inventors in the same general field (e.g., agriculture, medicine, business). (Themes 2, 3, 4)

**Source:** National Women's History Project, 7738 Bell Road, Windsor, CA 95492; (707)838-6000.

20. *Multiculturalism in Mathematics, Science, and Technology: Readings and Activities* (1993). $$

**Description:** This book of blackline masters contains readings and related activities on the work of 37 individual or groups of scientists, mathematicians, and inventors who are not white European or American males. For example, students read about the work of Harvey Itano, a Japanese-American sickle cell researcher, answer questions based on the reading, analyze cases to determine the chances of a couple's having a child with sickle-cell anemia, and analyze maps showing distribution of sickle cell anemia and malaria parasites. A large wall chart showing scientific contributions from various cultures is also included. (Theme 1, 2, 3, 4)

**Source:** Addison-Wesley Publishing Company, Route 128, Redding, MA 01867; (800)447-2226.

21. *Neolithic Revolution, The: The First Farmers and Shepherds: A Unit of Study for Grades 6-8*, by Linda Symcox (1991). $

**Description:** This four-lesson unit focuses on the neolithic revolution (8000-3500 B.C.), discussing the shift from hunting and gathering to herding and farming and the subsequent development of permanent communities. Development of decorative and religious arts is also covered. The teaching strategies used are primarily reading, discussion, and art projects; some excellent source material is included. (Themes 2, 3, 4, 5)

**Source:** National Center for History in the Schools, University of California, Los Angeles, Moore Hall 231, 405 Hilgard Avenue, Los Angeles, CA 90024-1521; (310)825-4702.

22. *Odyssey* (10 issues annually). $

**Description:** This magazine for upper elementary and middle school students primarily contains traditional science content, but does contain articles or activities on topics relevant to HNST. For example, in a regular column called "Future Forum," students are asked to respond to such questions as "If you could perform one experiment in space, what would it be?" "If you were the government and had an alien specimen, would you keep it top-secret or reveal it to the public?" "What portion of taxpayers' money should be spent on the space program?" (Themes 1, 3)

**Source:** Cobblestone Publishing, 7 School Street, Peterborough, NH 03450-1454; (603)924-7209.

23. *Opposing Viewpoints*.$

**Description:** Each book in this series for secondary students presents arguments made by prominent people on opposing sides of an issue. Issues relevant to HNST include biomedical ethics, genetic engineering, euthanasia, animal rights, AIDS, science and religion, and space exploration. A teacher's guide for each book provides suggestions for classroom use. (Themes 3, 4, 5)

**Source:** Greenhaven Press, Box 289009, San Diego, CA 92198-9009; (800)231-5163.

24. *Real Science, Real Decisions* (1990). $

**Description:** This paperback contains a collection of thinking activities on ethical dilemmas in science taken from *The Science Teacher*. Topics include fetal cell transplants, animal rights, acid rain, chemical warfare, genetic screening, and others. (Themes 3, 4, 5)

**Source:** National Science Teachers Association, 1840 Wilson Boulevard, Arlington, VA 22201-3000; (800)722-6782.

25. *The Rise of Modern Science: A Teacher's Guide*, by Allison Odell (1990). $$

**Description:** This unit intended for seventh-graders consists of 14 lessons designed to help students develop an understanding of changing methods and emerging knowledge in astronomy, medicine and the human body, and botany and zoology that led to science as we know it today. The unit opens with a summary of activity in classical Greece; this is followed by an examination of developments between 500 and 1789 A.D. in the Muslim Empire, China, and Europe. A variety of teaching strategies are used, and both primary and secondary sources are included. (Themes 1, 4, 5, 6)

**Source**: The Clio Project, School of Education, Tolman Hall 5507, University of California-Berkeley, Berkeley, CA 94720; (510)642-4793.

26. *Science and Public Policy: Uses and Control of Knowledge*, by Laurel R. Singleton (1993). $

**Description:** This unit examines critical questions related to science and public policy, including whether certain lines of investigation should ever be prohibited or kept secret and to what extent the citizen is obligated to understand science. Students explore these questions through wide-ranging historical and contemporary cases, including the trial of Galileo, J. Robert Oppenheimer's security clearance hearing, research linking violence with genetic causes, and the use of data from Nazi concentration camp experiments. A teacher's guide is available. (Themes 1-5)

**Source:** Social Science Education Consortium, P.O. Box 21270, Boulder, CO 80308-4270; (303)492-8154.

27. *Science/Technology/Society: Activities and Resources for Secondary Science and Social Studies*, edited by Laurel R. Singleton (1994). $

**Description:** This volume contains 45 model STS lessons that can be used by secondary teachers in a wide variety of courses. Such contemporary topics as bioengineering, ethics in medical care, recycling, and energy use are covered, as are important topics related to the history of science and technology. A wide range of instructional strategies are used. Lessons are keyed to common science and social studies courses. A bibliography of materials and organizations concludes the book. (Themes 1-5)

**Source:** Social Science Education Consortium, P.O. Box 21270, Boulder, CO 80301-4270; (303)492-8154.

28. *Scientific American Frontiers*. Free.

**Description:** PBS produces teaching guides to accompany its *Scientific American Frontiers* series, which can be taped for classroom use. The guides typically contain background notes and an activity for each story on *Frontiers*, plus interviews with educators and scientists and response forms for teachers and students to use in communicating with the series developers. Many of the programs deal with ethical issues and could also be used as the basis for exploring how scientists and technologists do their work. (Themes 1, 2, 3)

**Source:** *Scientific American Frontiers*, Connecticut Public Television, Box 260240, Hartford, CT 06126-0240; (800)523-5498.

29. *Scientific Revolution, The: A Unit of Study for Grades 7-10*, by Carole Collier Frick (1992). $

**Description:** The purpose of this unit is to help students explore the emergence of a new view of science during the 16th and 17th centuries. The four-lesson discussion-based unit draws heavily on primary sources, particularly the writings of Galileo, Bacon, and van Leeuwenhoek. (Theme 1, 3, 4, 5, 6)

**Source:** National Center for History in the Schools, University of California, Los Angeles, Moore Hall 231, 405 Hilgard Avenue, Los Angeles, CA 90024-1521; (310)825-4702.

30. *Social Issues Resource Series*. $$$/volume; $$$$ CD-ROM

**Description:** This series provides collections of articles on a wide variety of topics, including technology. The articles are timely, easily readable, and accessible. The materials are available in both print and CD-ROM and are updated annually.

**Source:** SIRS, Box 2348, Boca Raton, FL 33427; (800) 232-7477.

31. *Taking Sides: Clashing Views on Controversial Bioethical Issues*, by Carol Levine (1993). $

**Description:** This book suitable for skilled high school readers examines 20 central issues in health, medicine, and society, using a pro/con approach. Among the issues covered are reproductive choices, decisions about death, restricting access to health care, and human and animal experimentation. The author provides a background introduction and summary for each issue. (Themes 2, 3, 4, 5)

**Source:** Dushkin Publishing Group, Sluice Dock, Guilford, CT 06437; (800)243-6532.

32. *The Thomas Edison Book of Easy and Incredible Experiments: Activities, Projects, and Science Fun for All Ages*, developed by the Thomas Alva Edison Foundation (1988). $

**Description:** This book contains directions for a variety of experiments related to energy and technology. Approximately half of the experiments are historical, while half look at alternative energy sources and energy for the future. Information about Edison's work is infused throughout the book; highlights in his life are summarized in an appendix. (Themes 1, 2, 3)

**Source:** John Wiley and Sons, 605 Third Avenue, New York, NY 10158-0012; (800)225-5945.

33. *Time Travellers: Exploring the Impact of Technology*, by Diane Ecker and Jim Smoyer (1995). $$

**Description:** This unit is set up for use by teams in middle schools. It includes extensive planning support for the teacher as well as more than three dozen student activities and support for assessment. Several of the activities guide students through the creation of their own project book, which helps students explore different time periods in depth. There are options for including cooperative learning strategies and letting the students conduct self-evaluation.

**Source:** D.C. Heath, 95 Hayden Avenue, Lexington, MA 02173; (800) 334-3284 (ordering); (800) 824-7390 (fax).

34. *The Trial of John Scopes*, by Bill Lacey (1992). $$

**Description:** This simulation of the Scopes trial provides all the materials necessary for students to take part in a reenactment that will help them understand the conflicts that occur when scientific findings contradict strongly held beliefs. The simulation requires four class periods—one for preparation, two for conducting the trial, and one for debriefing. (Themes 3, 4, 5)

**Source:** Interact, Box 997, Lakeside, CA 92040; (619)448-1474.

35. Because one of the schools in this project was part of a bilingual science and technology program, we were made aware of several publishers who produce Spanish language versions. We list those publishers whose texts were helpful to participants in the project.

Editorial Everest, S.A.
Carreterra Leon— La Caruna, Km 5, LEON,
Espana (Spain)
sample book: Everest Illustrated Dictionary of the Sciences,
ISBN: 84-241-1520-1

Ediciones SM
Joaquin Turina, 39 28044 Madrid, Espana
Printers of the Aladdin series of books Ecolecion Tierraviva (Save Our Earth)
sample books: El Efecto Invernadero (greenhouse effect) and Los Residuos Toxicos (toxic wastes),
ISBN: 84-348-3490-1

Editorial Bruno
Marques de Mondejar, 32
28028 Madrid, Espana
Series of booklets on medical science and health in modern times (La Salud),
ISBN: 84-216-1463-0

## Teaching Resources: Computer Software

When planning how you would like to use software, decide if you want a program to be a tutorial (for individuals) or one the entire class uses together, such as a simulation. The simulation programs we have found to be most effective make use of a computer's calculation capabilities. For example, simulation software can indicate the impact an entire group or population is having after a series of decisions about an economic or environmental issue. When examining software simulations, we looked for good graphics and programs that would allow a large group to use one computer. Furthermore, the recommended programs are visually appealing and have a variety of screens.

36. *Atomic Age*. $$

**Description:** This CD-ROM for Mac/MPC (Windows) uses text, archival photographs, newsreel footage, maps, and primary source documents to trace the development of nuclear power. Also covered are arms control pacts, the physical effects of nuclear tests, and basic concepts of atomic physics. (Themes 1, 3, 4, 5)

**Source:** Social Studies School Service, 10200 Jefferson Boulevard, Box 802, Culver City, CA 90232-0802; (800)421-4246.

37. *Culture and Technology*. CD-ROM. $$$$

**Description:** This CD-ROM has 1800 lessons for science and social studies from eight curriculum projects funded by the National Science Foundation, but no longer in print. The search and retrieval system helps you sort through the lessons to find those that fit with your unit. The lessons are appropriate for grades 5-12.

Macintosh requirements:
1 megabyte of RAM or more
System 6 or higher

CD-ROM drive
graphics printer

PC requirements:
386 processor or higher
color graphics card and monitor
Windows 3.0
CD-ROM player with Microsoft MS DOS ROM extension
256 K minimum memory
DOS 3.1 or higher

**Source:** The Learning Team, 10 Long Pond Road, Armonk, NY 10504; (914)273-2226; (800)793-TEAM; (914)273-2227 (fax).

38. *Decisions, Decisions: The Environment.* $$$

**Description:** Tom Snyder produces a multitude of excellent software that pertains to HNST. We list one example. *Decisions, Decisions* is a computer simulation that can be used with science/social studies students from grades 5-12. It can be run using the following computer systems:

Macintosh - 3.5 disk (at least 1 meg of RAM)
Apple II - 5.25 disk (at least 64K of RAM)
MS-DOS - 5.25 disk (256K of RAM) or 3.5 disk

In this simulation, the class is divided into seven groups of four or more participants who work as advisors to the mayor. The mayor must deal with an environmental problem, pollution of the town's pond, while attempting to win re-election. Eventually, the advisory group finds out if the mayor is re-elected and how well they achieved their advisory group's goals. (Themes 4, 5)

**Source:** Tom Snyder Productions, 80 Coolidge Hill Road, Watertown, MA 02172-2817; (800)342-0236.

39. *Fish Banks, Ltd.* $$$

**Description:** *Fish Banks, Ltd.* is a simulation that can be used effectively with students from upper middle school through high school, and with adults of any age. It provides background in the complexity of environmental issues. In the simulation the participants (two to ten per company) form fishing companies that manage a company fleet, interact with other fishing companies, and maximize their assets. The computer program keeps track of the actual status of the fish populations and each company's financial status.

The simulation takes a minimum of two class periods (two hours) to run and could easily go for a week. The supplier will send a Macintosh or IBM PC program disk, 5.25 or 3.5, whichever you request. The Laboratory for Interactive Learning produces a newsletter that includes information on updates on the game, new data on world fisheries, and hints from teachers who have used the simulation. (Themes 3, 4, and 5)

**Source:** Laboratory for Interactive Learning, Institute for Policy and Social Science Research, Hood House, University of New Hampshire, Durham, NH 03824; (603)862-2186.

40. *Life Story.* CD-ROM $$$; videodisc (includes CD-ROM) $$$$

**Description:** *Life Story* is an "annotated movie" (for CD-ROM or videodisc) that allows students to explore the process that led to the discovery of DNA. Students can examine the evidence, clips from the movie *The Race for the Double Helix*, information about the people who contributed to the discovery of DNA, and the scientific concepts underlying the work, such as chromosomes or hydrogen bonds. The lack of linearity in this program will be a pleasure for students who feel confined by books. (Theme 1)

**Source:** Sunburst Communications, 101 Castleton Street, P.O. Box 100, Pleasantville, NY 10570-0100; (800)628-8897.

41. *MayaQuest.* $$$

**Description:** This 1995 release for students in grades 5-12 is billed as a "virtual field trip," taking students through the process of exploring archaeological sites in Central America. Through the process, students learn about the ancient Maya and their environment, astronomy, natural disasters, and connections with other civilizations. Activities to accompany *MayaQuest* are available on the Internet. System requirements to use this program are:

Macintosh—5MB, 68030, System 7.1, 13" monitor, and 256 colors

Windows 3.1—8MB, 486 5MB free on hard drive, sound card, and 256 colors

(Theme 1)

**Source:** Sunburst, 101 Castleton Street, Box 100, Pleasantville, NY 10570-0100; (800)321-7511.

42. *Physical Science I—Learning All About Machines & Mechanics.* $$

**Description:** This program introduces students to the laws of Aristotle, Galileo, and Newton, and provides a means of testing their theories by using simple machines. The concepts include work and friction, and the

laws of motion. The machines include inclined plane, levers, pulleys, wheels, axles, screws, and wedges.

Available for Macintosh, MS-DOS, and Windows. System requirements are:

Macintosh—2 megabytes free RAM and color monitor.

MS-DOS—640 K RAM hard disk space and color monitor (MCGA or VGA), and Sound Blaster for sound play (optional).

Windows—80286 processor (386 recommended), 4 MB, SVGA or Video and RAM monitor and graphics, Windows compatible mouse, DOS 3.1 or higher, Microsoft Windows 3.1 or higher; Soundbaster (optional).

This program is a tutorial for individual use or work in a computer lab. (Themes 1 and 2)

**Source:** Queue, Inc., 338 Commerce Drive, Fairfield, CT 06430; (800)232-2224.

43. *Smithsonian's America*. $$

**Description:** Students researching a wide variety of topics will find this Mac/MPC (Windows) CD-ROM useful. Among the product's six multimedia galleries is one on achievements in science, which includes artifacts, photos, documents, posters, and video segments drawn from the Smithsonian's collections (Themes 1, 4, 5)

**Source:** Social Studies School Service, 10200 Jefferson Boulevard, Box 802, Culver City, CA 90232-0802; (800)421-4246.

44. *Time Table of History: Science and Innovation*.$$

**Description:** This CD-ROM product provides a data base of information on the history of science and technology. Students can access information on the more than 6,000 events included by searching using keywords or time periods. Illustrations of various types are provided for many of the events. (Themes 1-6)

**Source:** Xiphias, 8758 Venice Boulevard, Los Angeles, CA 90034; (310)841-2790.

45. *The World Community*. $$

**Description:** This program connects the history of various locations in the Americas, Western and Eastern Europe, and Asia by describing environmental problems that are leading to (or perhaps forcing) efforts at international cooperation. This program is a tutorial to be used in individual work or in a computer lab. The program is available for Apple II and IBM. System requirements for the IBM are 256 K and color monitor. The program is appropriate for advanced middle school and for high school students. (Themes 3, 5)

**Source:** Queue, Inc., 338 Commerce Drive, Fairfield, CT 06430; (800)232-2224.

## Teaching Resources: Instructional Videos

Videos can present a wide range of HNST-related content, including illustrations of historical case studies, laboratories, and locations your students might not be able to visit. Students might easily watch a video, however, and have no sense of its purpose or relevance. Provide a context for viewing the video by linking its content to the topics students have been studying. Explain what students will be expected to do following the viewing; providing questions for students to have in mind as they watch the video is often helpful. Follow the video by asking recall questions as well as some thought-provoking and open-ended questions for discussion or writing.

46. *Acme Shorts*.$$$/video; $$$$/set

**Description:** These excellent three- to six-minute videos illustrate the nature of technology by explaining how many everyday inventions work. Some of the approximately 25 inventions include glue, camera F-stops, three-way light switches, scanning electron microscope, and dimmer switches. (Theme 2)

**Source:** Films for the Humanities and Sciences, Box 2053, Princeton, NJ 08543; (800)257-5126.

47. *A Brief History of Chemistry,* 19 minutes. $$$

**Description:** This video describes the development of thought that led to the field of chemistry and describes in particular the work of Lavoisier. Of the six Hawkhill videos we previewed, this one is the best in terms of being well organized and making good use of video to display a variety of images. (Themes 1, 4)

**Source:** Hawkhill Associates, Inc., 125 East Gilman Street, P. O. Box 1029, Madison, WI 53701-1029; (800)422-4295.

48. *Connections Series,* 10 videos, 52 minutes each. $$$/tape; $$$$/set

**Description:** In this series, James Burke documents the development of many inventions that have changed our lives. His thesis that one type of invention necessarily led to another strikes some historians as too deterministic, but many of his case studies (such as how the plough changed social structure) are fascinating and illuminating. (Themes 2, 4, 5)

**Source:** Ambrose Video Publishing, Inc., 1290 Avenue of the Americas, Suite 2245, New York, NY 10104; (800)526-4663.

49. *Connecting the Past with the Future: Women in Mathematics and Science,* 4 videos, approximately 45 minutes each. $

**Description:** These 1994 videos focus on the lives and work of Ada Lovelace (computer science); Mary Somerville (astronomy); Florence Bascom (geology); and Maria Goeppert-Mayer (physics). They contain segments in which students have called in to ask questions of modern scientists being interviewed on the programs. The videos are professionally and energetically done. (Themes 1, 2, 3)

**Source:** Women's Center, Western Illinois University, Macomb, IL 61455; (800)322-3905.

50. *The Day the Universe Changed,* 10 videos, 54 minutes each. $$$/tape; $$$$/set

**Description:** James Burke wrote this series several years after the *Connections* series. It continues a similar theme, but uses different examples. Burke selects incidents that show how accumulation of knowledge led to change. For example, Burke documents the cholera epidemics that struck London. As a few researchers studied the epidemics over the course of years, they realized that the biggest factor in safety was a neighborhood's elevation above the Thames river. The means of recording this data led to the topographic map as well as to insurance, because risk was a factor that could be predicted. (Themes 1, 2, 5)

**Source:** Churchill Films, 12210 Nebraska Avenue, Los Angeles, CA 90025; (310)207-1330.

51. *The Earth Has a History.* $

**Description:** This video illustrates the nature of science by examining some of the questions geologists have traditionally asked. The geologist in the film uses spectacular natural examples to illustrate how people conceived the idea of a geological time scale. (Theme 1)

**Source:** Geological Society of America, P.O. Box 9140, Boulder, CO 80301; (800)GSA-1988.

52. *Earth Revealed,* 60 minutes. $$

**Description:** This video describes how the acquisition of knowledge gradually led to the theory of plate tectonics. It illustrates the nature of science, particularly through the course of interviews with famous geologists such as Tanya Atwater and Gary Ernst. The intended audience is secondary and college students. (Theme 1)

**Source:** The Annenberg/CPB Collection, P. O. Box 2345, S. Burlington, VT 05407-2345; (800)LEARNER.

53. *Ethics in America: The Human Experiment,* 60 minutes. $$

**Description:** This video presents a panel of experts discussing ethical issues related to medical research. Among the panelists are Antonin Scalia, C. Everett Koop, Joseph Califano, Ellen Goodman, the editor of the *New England Journal of Medicine*, the CEO of Upjohn, government and private sector researchers, and others. The discussion begins with a hypothetical AIDS patient who wants to get into a research program. Among the many questions explored are what constitutes informed consent, whether placebos should be used if a drug being tested shows potential, and how scientific information should be communicated with the public. (Themes 1, 3)

**Source:** The Annenberg/CPB Collection, P. O. Box 2345, S. Burlington, VT 05407-2345; (800)532-7637.

54. *Green Gold: From the Maya to the Moon,* 30 minutes. $

**Description:** This video documents humanity's dependence upon a few types of plants, such as corn and potatoes. These plants were brought to Europe by explorers in the 16th and 17th centuries and are actually worth far more than the gold the European explorers sought. Also explained are the effects of modern agricultural technology in hybridizing and reducing the genetic diversity of seeds, and the potential danger this poses. (Themes 2, 3, 5)

**Source:** Jeanne Gleason, New Mexico State University, Agricultural Communications, Box 30003, Dept. 3AI, Las Cruces, NM 88003; (505)646-3228.

55. *The Industrial Revolution*, 23 minutes. $$$

**Description:** This film uses dramatic recreations and period artwork to trace the history of the Industrial Revolution in the United States. Topics covered are the rise of urban centers, the impact of Samuel Slater's mill, the creation of the factory system, and the split between the industrialized North and agricultural South. (Themes, 2, 4, 5)

**Source:** Encyclopaedia Britannica, 310 South Michigan Avenue, Chicago, IL 60604-9839; (312)347-7959.

56. *The Iron Road, The American Experience Series,* 58 minutes. $$

**Description:** This video describes the building of the first transcontinental railroad in North America. As is typical of the American Experience series, the photographs used are excellent, and the narration is thoughtfully organized and interesting. This episode provides an example of a technology, the values that underlay its use, and the impact it had. (Themes 2, 3, 5)

**Source:** PBS Video, 1320 Braddock Place, Alexandria, VA 22314; (800)328-7271.

57. *Islam and the Sciences*, 23 minutes. $$$

**Description:** The narrator describes how the pursuit of knowledge was and is integral to the Muslim religion and led to the preservation and enhancement of knowledge from the Greeks. Topics included are the use of devices such as the astrolabe and its modern counterparts; mapmaking; advances in mathematics, such as Arabic numerals and trigonometry; and the unison between artistic beauty and technical practicality in many Islamic inventions. (Themes 1, 2, 3, 4)

**Source:** Social Studies School Service, 10200 Jefferson Boulevard, Box 802, Culver City, CA 90232-0802; (800)421-4246.

58. *Mindworks*, 120 minutes. $

**Description:** This video contains 15-minute segments about seven scientists and inventors: Galileo, Emilie du Chatelet, George Ferris, Count Rumford, Granville Woods, Isaac Newton, and Marie Curie. The final segment is about modern problems in physical science as exemplified by the Mars Rover. Each segment is accompanied by a set of student materials and activities. The video and instructional packets are currently being field tested. (Themes 1, 2, 3)

**Source:** Dr. Barbara J. Becker, WestEd, 4665 Lampson Avenue, Los Alamitos, CA 90720; (310)985-9109.

59. NOVA: *Brain Transplant,* 60 minutes. $$$

**Description:** In California, a series of people are taken to emergency rooms. Each of the patients is mysteriously paralyzed. The mystery takes years to unravel. It turns out that a synthetic illicit drug, intended to mimic heroin, has had the tragic consequence of inducing a disease like Parkinson's disease. The addicts eventually become crucial in the study of the disease, and advances in technology arise out of their personal tragedies. (Themes 1 and 3)

**Source:** Films for the Humanities, Inc., Box 2053, Princeton, NJ 08543-2053; (800)257-5126.

60. *Rachel Carson's Silent Spring, The American Experience Series*, 57 minutes. $$

**Description:** This video provides background on Rachel Carson's career as a biologist and as editor for the U.S. Fish and Wildlife Service, prior to her work on *Silent Spring*. In addition to the interesting personal background about Carson's life, the video contains amazing footage of old advertising clips about pesticides and of the scientists who tried to discredit Carson's character and her work. (Themes 3, 4, 5)

**Source:** PBS Video, 1320 Braddock Place, Alexandria, VA 22314; (800)328-7271.

61. *The River Ran Red: The 1892 Steel Strike*, 58 minutes. $$

**Description:** Labor and economic history are interwoven with the history of technology, a relationship that is clear in this recent documentary. The film chronicles the 1892 Homestead Steel Strike, looking at such issues of interest to HNST teachers as the impact of industrialization on workers and the conflict between the profit motive of industry and the desire of workers to maintain a decent lifestyle. Readings from autobiographical accounts of the participants are interspersed with the narration. A companion volume of primary source documents is available from the publisher. (Themes 3, 4, 5)

**Source:** University of Pittsburgh Press, 5633 Woodmont Street, Pittsburgh, PA 15217-1244; (412)421-4789.

62. *Sit Down and Fight: Walter Reuther and the Rise of the Auto Workers' Union*, 58 minutes. $$

**Description:** Advances in automobile production technology and resultant profits did not necessarily lead to improved quality of life for the automobile assembly

workers. The video documents the courage and the triumphs of auto workers in the 1930s and 1940s and contrasts their values with those of the factory owners. It also provides an interesting context for discussing the conditions of employees and former employees in Michigan today. (Themes 3, 5)

**Source:** PBS Video, 1320 Braddock Place, Alexandria, VA 22314; (800)328-7271.

63. *War and Peace in the Nuclear Age: Program 1: Dawn*, 60 minutes. $$

**Description:** This video dramatically illustrates the values that encouraged the development of nuclear technology and the influence of technology on culture, society, and the environment. The producers made use of historical film footage and video clips from the 1930s to the present. The video's references to the Soviet Union make the danger of political instability seem even more pressing. (Themes 3, 4, 5)

**Source:** The Annenberg/CPB Collection, P. O. Box 2345, S. Burlington, VT 05407-2345; (800)LEARNER.

64. *Women of the Heartland*. 23 minutes. $$$

**Description:** This video shows the daily lives of farm women during the first half of the 20th century, demonstrating the interrelationships among a way of life, technology, social trends, and political changes. The video combines first-person accounts, reenactments, archival materials, and period music. (Themes 2, 4, 5)

**Source:** United Learning, 6633 West Howard Street, Niles, IL 60714; (800)759-0362.

## Teaching Resources: Commercial Videos

Commercial movies can provide a motivating way to show students that science and technology are important beyond the classroom. Before showing any movie to your class, preview it in its entirety. Previewing the film will allow you to ensure that the movie would not be offensive in your community and to plan for pre- and post-viewing activities. Pre-viewing activities are important in setting a context for viewing. What questions should students have in mind as they are watching? What is their purpose in viewing the video? How does the video relate to the larger instructional unit in which it is being used?

Post-viewing activities are critical to helping students develop understanding. Immediately following the video, a brief general discussion of the movie may be helpful. This discussion can be followed by a discussion targeted at your purposes in using the film. Preparing some carefully framed questions in advance will be useful in directing the discussion. Having students role play how they would have resolved a conflict in a film is another useful technique, especially when you are focusing on ethical issues related to science and technology. Other possible post-viewing activities include writing exercises and art projects.

Although some movies are too long to show in class in their entirety, many teachers have found that showing the most salient part of a film in class is sufficient for instructional purposes. Often students become so interested in the film that they make time to see the rest of the film before school, during lunch hours, or after school.

Several cautions are in order in using theatrical films. First, be sure that you follow all district and school procedures for showing films with R or PG-13 ratings.

Second, while films can be motivational, carefully evaluate whether the film you are considering includes enough content to merit the time you will devote to it. For example, the recent film *The Net* (1995, PG-13) raises interesting questions related to technology and culture: In an era of "cyber-commuting," can a person become completely isolated from real human relationships? If so, what are the implications for the individual and for society? Can privacy exist in the computer age? Yet the film is primarily a conventional thriller. Furthermore, much of the technical information is, according to experts, inaccurate or wildly unlikely. Thus, use of the film could open you to criticism that you are wasting valuable instructional time on a frivolous "Hollywood" production.

Finally, it is well to remember that in order to create dramatic tension, movies need conflict, and conflict in movies touching on science and technology often derives from negative effects of technological change or from conspiracies blocking the efforts of the "gallant scientists." Thus, in selecting films—and other material—teachers should strive for balance, and the biases in films should be subjected to rigorous analysis after viewing.

Below we suggest only a few of the many films that could be used to develop understanding of the HNST themes; we hope these suggestions will spark your own thinking about appropriate films for use in the HNST classroom. The many film and video guides available can help you select a film that is suited to your curriculum. An especially well indexed guide is *The Video Hound's Golden Retriever Film Guide* (Detroit: Visible Ink Press, 1994). Because the movies are available on video and can thus be rented at your local video store, we do not provide source information for most of the films.

65. *And the Band Played On* (1993, PG).

**Description:** This film provides insights into the nature of science and the factors that influence what science gets done. It deals with conflicts about what constitutes acceptable evidence in medical science, what information should be made public concerning treatments and disease, and factors that influence whether research money is available to study certain diseases. The film is somewhat long for classroom use, but segments that illustrate particular points can easily be identified. For example, scientific thinking is beautifully illustrated when the CDC researchers decide how to gather evidence that the disease is transmitted through sexual activity and then through the blood supply. (Themes 1, 3, 4)

66. *Apollo 13* (1995, PG).

**Description:** This film chronicles the Apollo 13 mission, commanded by veteran astronaut Jim Lovell. When an in-flight explosion compromises the mission, the three astronauts aboard and hundreds of scientists in Houston must solve a series of problems in order to ensure the astronauts' safe return. The movie could prompt discussion of a wide variety of issues related to the HNST themes: the dominance of the early space program by white male scientists and engineers, the influence of public opinion and interest on science, the limits of technology, the nature of technological and scientific problem solving, and the like. Since the movie is well over two hours long, we recommend that teachers select segments based on the issue or issues they wish to pursue. (Themes 1, 2, 3)

67. *The Conversation* (1974, PG).

**Description:** The impact of technology on privacy is explored in Francis Ford Coppolla's *The Conversation.* The story of a wiretapping expert's part in a murder helps develop the theme of how misuse of new technologies can erode privacy and democracy itself. (Themes 3, 5)

68. *Gizmo* (1977, G).

**Description:** This 77-minute primarily black-and-white documentary tells the stories of people obsessed with invention. Film of many of the inventions is amusing. A teacher need only show portions of the movie for students to get a sense of the diverse problems of adaptation that humans have invented technologies to address—sometimes successfully, sometimes not. (Theme 2)

69. *Gods Must Be Crazy, The* (1984, PG).

**Description:** The premise of this movie's opening scenes is one that should promote student discussion about the relationship between technology and culture. A soda bottle falls from an airplane into the Kalahari Desert, where Bushmen find it, develop alternative uses for it, and eventually decide that it is evil. Students could consider how they might react if a technology with which they were unfamiliar suddenly fell from the sky. Would they and their friends fight over it, as the children did in the movie? Would they develop alternative uses? The rest of the movie is basically a slapstick comedy not directly applicable to HNST. (Themes 2, 4, and 5)

70. *Gorillas in the Mist* (1989, PG-13).

**Description:** *Gorillas in the Mist* is the story of naturalist Dian Fossey, who—though trained as a physical therapist—spent her life studying and protecting the mountain gorillas of Africa. The scenes in which Folley first tries the techniques she developed to allow close observation of the gorillas are both moving and an excellent stimulant for discussion of the role of observation in science. The film, or portions thereof, could also serve as a springboard for discussing a number of other topics and issues related to the nature of science: the effect of social/political phenomena on science (e.g., the civil war in the Congo and poverty in Rwanda), the requirements that funders (in this case National Geographic) may place on scientists, the relationship between knowledge and action, and the role that people not trained as scientists can play in doing scientific research. (Themes 1, 3, 4)

71. *Inherit the Wind* (1960).

**Description:** How beliefs influence societal response to science, specifically Darwin's theory of evo-

lution, is dramatized. The movie tells the story of the 1925 Scopes Trial in Tennessee, in which attorneys Clarence Darrow and William Jennings Bryan argued the merits of the theory. If you use this, also see Garry Wills' book *Under God,: Religion and American Politics* (New York: Simon and Schuster, 1990), which corrects some of the historical innacuracies in the play. (Theme 4)

72. *Lorenzo's Oil* (1993, PG-13).

**Description:** A young boy's mysterious illness and his parents' quest for a cure illustrate the nature of modern science and the factors controlling research. Many of the issues raised in *And the Band Played On* are also raised here, in a context that may be less controversial because AIDS is not involved. Ethical issues abound. (Themes 1, 3, 4)

73. *Modern Times: Charlie Chaplin Centennial Collection* (1936).

**Description:** The first 15 minutes of this video brilliantly and humorously depict assembly line technology in factories of the United States. It also conveys the dehumanizing effects of industrialization. After the first 15 minutes, some scenes might be too risque for use in most secondary classrooms. The movie might easily provoke discussions on the nature of technology: How was it depicted? Why were people hungry? Was technology only humorous, or was it dangerous as well? (Themes 2, 3, 5)

**Source:** Social Studies School Service, 10200 Jefferson Boulevard, Box 802, Culver City, CA 90232-0802.

74. *Mosquito Coast* (1986, PG).

**Description:** This dark film tells the story of Allie Fox, an inventor disillusioned with American society and convinced that nuclear war is imminent. Fox moves his family to the Central American jungle, where he dreams of building a new society based on his own inventions. Although he despises missionaries, he treats technology as a redeeming force ("Ice is civilization," he tells his children). The best segment for use in illustrating the HNST themes is the building of the compound in the jungle, culminating with pollution of the river as a result of one of his inventions. (Themes 3, 4, and 5)

75. *Outbreak* (1995, R).

**Description:** Two formerly married virologists work frantically to find a treatment for the Motaba virus, carried to the United States from Africa by a monkey who is released into the wild. Their efforts are thwarted by military doctors who have known about the virus for 30 years. While the movie's conspiracy theory seems heavy handed, the manner in which the scientists approach their study of the virus is interesting and could profitably be compared to how the AIDS virus has been studied. (Themes 1, 3, 4)

76. *Sneakers* (1992, PG-13).

**Description:** *Sneakers* could be used to spark a discussion of whether technology is value-free. At the center of the movie is a revolutionary code-breaking technology, which falls in and out of the hands of the movie's "heroes." Students might consider whether the technology (or any technology) is "good" when used by the "good guys" and "bad" when used by the "bad guys," or whether certain values are inherent within the particular technology (that is, because this technology is designed to break codes, is it inherently intrusive and antithetical to privacy?). (Themes 2, 3)

77. *Soylent Green* (1973, PG).

**Description:** In 2022 New York, the distinction between people and technology has blurred—women are merely furniture in rich men's apartments, researchers are known as books, and—as the cop investigating a murder discovers—the new popular food, Soylent Green, is made of people. The implications of considering people and technologies as indistinguishable should promote student discussion of the nature of technology. (Themes 2, 3)

78. *Tucker: The Man and His Dreams* (1988, PG).

**Description:** The influence of society on technology is examined in the film *Tucker: The Man and His Dreams*. The movie tells the story of maverick auto designer Preston Tucker, who introduced such design features as disc brakes, fuel injection, and seat belts just after World War II. His dream of a progressive automobile was never realized, however, because the big Detroit auto companies conspired to destroy his company. (Themes 2 and 4)

79. *Whose Life Is It, Anyway?* (1981, R).

**Description:** This film chronicles the struggle of a sculptor, paralyzed in a car accident, to win the right to refuse medical treatment. Because of nudity in the film, teachers should select segments for discussion. Two scenes that raise many questions about the patient's rights and informed consent in the era of modern medi-

cine are the sculptor's conversation with the hospital psychiatrist about how patients can use medical knowledge to make decisions and the legal hearing in which the sculptor seeks a writ of habeas corpus to allow him to leave the hospital,where doctors insist on providing treatment he has tried to refuse. (Themes 3, 5)

## Interesting Readings for Teachers: History and Nature of Science

The following works are primarily books on the history and nature of science, although a few focus on science education. Our main goal in including these references was to encourage you to read some classic and/or stimulating works in this field you are teaching about. However, you may find some of the books useful as sources for student readings or inspiration for lessons or units you wish to teach.

80. *Benchmarks for Science Literacy*, developed by Project 2061 (January 1993). $

**Description:** This curriculum-planning tool provides standards for science literacy. Especially helpful are Chapter 1, "The Nature of Science," and Chapter 10, "Historical Perspectives." The 22 pages of Chapter 10 serve as an excellent introduction or review for teachers of the history of science. The works of Copernicus, Galileo, Kepler, Newton, Lavoisier, Lyell, Darwin, Pasteur, Wegener, Einstein, and the Curies are summarized in terms of two categories: what middle school students should know and what high school students should know. A brief section on the Industrial Revolution describes how science teachers might integrate study of this topic with social studies teachers.

**Source:** Oxford University Press, 2090 Madison Avenue, New York, NY 10016; (800)334-4249.

81. *Chaos: Making a New Science*, by James Gleick (1987). $

**Description:** This book chronicles the paths that scientists in a variety of fields took in developing the field of study known as chaos. Although the book is written for a lay audience, a solid background in math is helpful to understanding the concept of chaos. The history of chaos illustrates well some important ideas about the nature of science—for example, the tentative nature of knowledge and the different paths through which theory is developed.

**Source:** Penguin Books, 120 Woodbine Street, Bergenfield, NJ 0762; (800)526-0275.

82. *Code of Codes, The: The Scientific and Social Issues of the Human Genome Project*, edited by Daniel J. Kevles and L. Hood (1992). $ (paperback)

**Description:** This is a reasonably complete account of the scientific and technological aspects of the Human Genome Project, complemented by the philosophical, ethical, legal, and policy aspects of the project and its products.

**Source:** Harvard University Press, 79 Garden Street, Cambridge, MA 02142; (617)495-2577.

83. *Discoverers, The: A History of Man's Search to Know His World and Himself*, by Daniel J. Boorstin (1985). $$

**Description:** This book is particularly interesting because Boorstin documents the work of Islamic scientists during the time of the Dark Ages in Europe. Geography and earth science teachers may find this book useful because of the sections on Islamic map-making. For example, Al-Biruni and a crew of assistants discovered how to calculate latitude or distance from the equator. One of the steps in their process was to measure the length of a day on a north-south transect on the longest day of the year.

**Source:** Abrams, 100 Fifth Avenue, New York, NY 10011; (800)345-1359.

84. *Mismeasure of Man*, by S.J. Gould (1981). $

**Description:** Gould documents the 19th-century studies of brain size and facial features that were used to reinforce social prejudices. Gould always does an excellent job of developing historical themes and highlighting the nature of science and the ways in which science and its applications reflect societal values and perceptions. A very readable book.

**Source:** W.W. Norton, 500 Fifth Avenue, New York, NY 10110; (800)233-4830.

85. *National Science Education Standards*, developed by National Research Council (1996). $

**Description:** This book describes the standards for teaching science in the United States. It includes standards for teaching, professional development, assessment, content, programs, and systems. Half of the

content standards focus on ideas related to the history and nature of science and technology. All of the other areas are consistent with the ideas in this resource guide. The standards for teaching are especially relevant, stressing inquiry and discourse.

**Source:** National Academy Press, 1201 Constitution Avenue, NW, Lockbox 285, Washington, DC 20055 (800)624-6242 (ordering); (202)334-2451 (fax).

86. *Science and Human Values*, by J. Bronowski (1965). $

**Description:** Bronowski was an eye-witness to the devastation in Nagasaki, Japan, in 1945. He visited the site shortly after the A-bomb was dropped. That experience moved him to write the essays that make up this book. These brief essays range from deep soul-searching and definitions of human values to fascinating incidents from the Scientific Revolution. The essence of Bronowski's argument is that all discoveries require more than logic, and that we must not view science as separate from our daily endeavors. He asks the reader to find the unity among scientific and other human endeavors. For example, he argues that the arts and sciences are not separate, because the impetus for both is creativity. Bronowski states that "to abdicate an interest in science is to walk with open eyes toward slavery."

**Source:** Peter Smith Publishers, Inc., 5 Lexington Avenue, Magnolia, MA 01930; (508)525-3562.

87. *Science Teaching: The Contribution of History and Philosophy of Science*, by Michael Matthews (1994). $

**Description:** This book examines the importance of philosophical perspectives in scientific interpretation. For example, naming a concept, such as gravity, does not imply a depth of understanding. Matthews examines how philosophy of science has and should affect the course of science teaching.

**Source**: Routledge, 29 West 35th Street, New York, NY 10001; (800)634-0364.

88. *Short History of Chemistry, A*, by Isaac Asimov (1979). $$

**Description:** One of Asimov's many history of science texts, this book chronicles the development of chemistry from prehistoric people's early experiences with fire and metal, through alchemy and the development of the modern field of chemistry. This would be a good book for students to read, especially those who are grappling with what chemistry really is. If you decide to use this book with students, we recommend these chapters in particular: 1 (The Ancients), 3 (Transition), 4 (The Gases), and 8 (The Periodic Table).

**Source:** Greenwood Press, 88 Post Road West, Westport, CT 06881; (800)225-5800.

89. *Science for All Cultures* (1993). $

**Description:** This booklet contains 14 articles that appeared in one of the NSTA journals recently. Each article focuses on an aspect of science and culture including the contributions to science from people of cultures rarely acknowledged in the history of science. Other articles focus on how to help students from diverse cultures stay interested and successful in science.

**Source:** National Science Teachers Association, 1840 Wilson Boulevard, Arlington, VA 22201; (800)722-6782.

90. *Structure of Scientific Revolutions, The*, by Thomas S. Kuhn (1962, 1970). $

**Description:** This seminal text in the history and nature of science has influenced the work of both historians of science and science educators. For example, it is increasingly common to hear educators speak of a paradigm shift, and this book is one of the sources of that vocabulary. Kuhn examines the nature of science, the paradigms or models that have guided research, and the re-evaluation and transformations necessary for acceptance and assimilation of scientific discovery.

**Source:** University of Chicago Press, Box 37005, Chicago, IL 60637; (800)621-2736.

91. "Students' and Teachers' Conceptions of the Nature of Science: A Review of the Research," by Norman G. Lederman (1992).

**Description:** This journal article provides a comprehensive review of the research related to how students and teachers understand the nature of science. If you are interested in understanding what your students might not know and what the research says about those misunderstandings, this will be an interesting article.

**Source:** *Journal of Research in Science Teaching*, Volume 29, number 4, pages 331-359.

92. *Two Cultures, The*, by C.P. Snow (1961). $

**Description:** In this small book, C. P. Snow describes the anti-scientific stance of intellectuals in the humanities in Britain in the 1940s and 1950s. His statements provide an interesting insight into British and

American society during post-World War II and the Cold War era. Many of his statements could be made about academia in the 1990s.

**Source:** Cambridge University Press, 40 West 20th Street, New York, NY 10011; (800)872-7423 (outside NY); (800)227-0247 (NY only).

93. *What Is This Thing Called Science?*, by A.F. Chalmers (1982).

**Description:** This is an excellent introductory and easily read survey text on the nature of science. Following an overview of the philosophical underpinnings of scientific thinking, concise and analytical summaries of the primary contemporary views on the nature of science are provided (i.e., Popper, Lakatos, Kuhn, and Feyerabend).

**Source:** International Specialized book Services, Inc., 5602 N.E. Hassalo Street, Portland, OR 97213-3640; (800)547-7734.

94. *White Trash: The Eugenic Family Studies, 1877-1919*, edited by N.H. Rafter (1988). $$

**Description:** This work focuses on the eugenics movement in the United States and its relationship, among other things, to American immigration policy in the early part of this century. This is an interesting treatment of the ways in which scientists and other individuals in positions of influence manipulated science to support prevailing, but mistaken, notions of human behavior.

**Source:** Northeastern University Press, 360 Huntington Avenue, Huntington Plaza, Suite 272, Boston, MA 02115; (800)666-2211.

## Interesting Readings for Teachers: History and Nature of Technology

The books annotated in this section focus on the history and nature of technology. Together, they constitute an excellent starting point for broad-based knowledge in the field. Several of the books are written in a style that would be accessible for high school students. In addition, the books on science education annotated in the previous section, such as *Benchmarks for Science Literacy* and *National Science Education Standards*, are also of interest to teachers primarily interested in technology.

95. *Engines of Change: The American Industrial Revolution, 1790-1860*, by Brooke Hindle and Steven Lubar (1986). $

**Description:** This book derived from an exhibition at the Smithsonian's Museum of American History also titled "Engines of Change." The book is rich in material on the technology of the United States during the period from the Republic's founding to the Civil War. Its many photographs, plates, and diagrams of technologies of the period are especially noteworthy. Similarly, its exposition of the workings of various technological artifacts are clear and understandable. Students could use portions of this book.

**Source:** Smithsonian Institution Press, 470 L'Enfant Plaza, Suite 7100, Washington, DC 20560; (202)287-3738.

96. *Evolution of Technology, The*, by George Basalla (1988). $

**Description:** A volume in the Cambridge History of Science Series, this book presents a theory of the evolution of technology. It is based on recent scholarship in the history of technology, economic history, and anthropology. Three themes recur throughout the book: (1) diversity—there is a vast number of made things; (2) necessity—technological innovation is culturally-defined, and not driven by biological necessity; and (3) technological evolution—an analogy derived from biology helps explain the appearance and selection of novel artifacts. The book presents a very large number of concrete case studies—drawn from earliest times to the modern United States—which Basalla uses to illustrate the major features of his theory.

**Source:** Cambridge University Press, 40 West 20th Street, New York, NY 10011; (800)872-7423 (outside NY); (800)227-0247 (NY only).

97. *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave*, by Ruth Schwartz Cowan (1983). $

**Description:** In thinking about the history of technology, many of us begin with the assumption that technology implies such "big technologies" as the locomotive, the printing press, the power textile loom, or something similar. Yet such important technologies as the cook stove, vacuum cleaner, or the microwave may

be more important because they actually affect more people and the nature of their day-to-day lives at any given time. Furthermore, women's role in the creation and use of technology has, until quite recently, often been overlooked. To leave out the historical experiences of half the population is surely to distort the history of technology. This is, of course, not to say that women encounter technology only (or even principally) through artifacts used in the household. Nevertheless, many women—and men and children—do encounter technologies of this kind; and often with unforeseen consequences.

**Source:** Basic Books, 10 East 53rd Street, New York, NY 10022; (800)242-7737.

98. *Nuts and Bolts of the Past: A History of American Technology, 1776-1860*, by David Freeman Hawke (1988).

**Description:** Forty-two case studies in the history of technology in American history before the Civil War comprise this book. These case studies are usually short (5 to 10 pages) but well-written and to the point. Hawke develops the case studies to illustrate larger themes in the history of technology. While often using biographies of various innovators and inventors, Hawke is no subscriber to the "genius school of technological development." Indeed, his treatment of Eli Whitney, for example, is titled "Song and Dance Man?," suggesting the idea that inventors often try to (or have to) create the needs and demands that their inventions supposedly seek to fulfill. Students should be able to use the case studies profitably.

**Source:** Out of print; available in libraries.

99. *Technology in America: A Brief History*, by Alan I. Marcus and Howard P. Segal (1989). $

**Description:** *Technology in America* is a very brief, but very useful, overview of the history of technology in America. The book gives virtually no attention to the state of technology in the Americas before European exploration and settlement. Its organization is divided into three major chronological periods: Part One, "From the Old World to the New: 1607 to the 1870s"; Part Two, "Systematizing America: The 1870s to the 1920s"; and Part Three, "From Industrial America to Post-Industrial America: The 1920s to the Present." Students could use this book directly.

**Source:** Harcourt Brace Jovanovich, 1250 Sixth Avenue, San Diego, CA 92101; (800)346-8648.

100. *Technology in America: A History of Individuals and Ideas*, edited by Carroll W. Pursell, Jr. (1981). $

**Description:** The biographical case studies contained in this book have been written by some of the leading scholars in the field. The case studies are not written to celebrate individual geniuses, but to illustrate broader themes in the history of technology in the United States. These range from the work of artisans during America's "wooden age" to the history of space flight.

**Source:** MIT Press, 55 Hayward Street, Cambridge, MA 02138; (800)356-0343.

101. *Technology in Western Civilization*, Vol. I, *The Emergence of Modern Industrial Society, Earliest Times to 1900* and Vol. II, *Technology in the Twentieth Century*, edited by Melvin Kranzberg and Carroll W. Pursell, Jr. (1967).

**Description:** These volumes contain articles written by some of the best scholars of the history of technology. The articles comprising this collection vary in quality, but all contain a wealth of information. Volume I is divided into five parts: Part I, "The Emergence of Technology"; Part II, "Background of the Industrial Revolution, 1600-1750"; Part III, "The Industrial Revolution, 1750-1830"; Part IV, "The Age of Steam and Iron, 1830-1880"; and Part V, "The Promise of Technological Fulfillment, 1880-1900."

Volume II is organized in twelve parts: Part I, "Introduction"; Part II, "Rationalization and Its Consequences"; Part III, "Transportation"; Part IV, "Materials and Structures"; Part V, "Energy Sources"; Part VI, "Electronics and Communications"; Part VII, "The Food Revolution"; Part VIII, "Land Use and Resources"; Part IX, "Technology and the State"; Part X, "Technology in War"; Part XI, "Scientific Research, Technology, and Automation"; and Part XII, "Space, Culture, and Technology."

**Source:** Out of print; available in libraries.

102. *Technology in World Civilization: A Thousand Year History*, by Arnold Pacey (1990). $

**Description:** Many general histories of technology have tended to focus on the West. In this book, Pacey takes a more global view of technological development. He argues that the process of creating technologies is

the result of what he calls a complex dialogue or dialectic among societies and cultures. In this, inventions are often borrowed by one culture from another and adapted to the borrowers' own ends. Sometimes even "a mere rumor of an unfamiliar technique" may produce new ways to achieve similar results. The failure to comprehend this sort of cultural dialogue, Pacey argues, has often led to misguided efforts to force the transfer of technology from one culture to another without allowing for what he calls "responsive innovation" (i.e., tailoring a technology to the needs and cultural and social style of the new host).

**Source:** MIT Press, 55 Hayward Street, Cambridge, MA 02138; (800)356-0343.

103. *Technology's Storytellers: Reweaving the Human Fabric*, by John M. Staudenmaier (1985). $

**Description:** This book appears to be both narrow (i.e., a taxonomy of the articles appearing in the Society for the History of Technology journal, *Technology and Culture*) and broad (i.e., no less than a thorough-going critique of the history of technology field). The importance of the book lies in its analysis of the assumptions and the writings of historians of technology. In doing so, it speaks to many of the most important themes (or topics) in the history of technology. These include such items as the historical relationship between science and technology, the debate concerning technological determinism, the idea of technological "momentum," and the play of knowledge and creativity in the emergence of new technologies, among others. This book is certainly not for direct use by students, but it will provide the reader with an intellectual context for judging other works in the history of technology they may encounter.

**Source:** MIT Press, 55 Hayward Street, Cambridge, MA 02142; (800)356-0343.

104. *Technopoly: The Surrender of Culture to Technology*, by Neil Postman (1993). $

**Description:** In this book, Postman warns against the tyranny of machines over humans. He argues that modern society has been transformed from one that uses technology for human ends to one in which technology is so pervasively and mindlessly embraced that it tends to subvert human ends. In general thrust and tone, this book is similar to Postman's *Amusing Ourselves to Death*, a critique, in part, of the mass media's impact and influence on the way we think and act.

**Source:** Vintage Books, 201 East 50th Street, 31st Floor, New York, NY 10022; (800)726-0600.

## Interesting Readings for Teachers: Newsletters and Journals

The newsletters and journals annotated in this section are primarily devoted to substantive issues in the history and nature of science and technology; these scholarly publications can be sources of information that you can use in designing lessons or amplifying student readings or lectures. A few journals listed focus on pedagogy. For more lesson ideas related to HNST topics, the general teaching journals in science and social studies—*Social Education*, *Science Scope* (middle school), and *The Science Teacher* (high school)—can also be helpful.

105. *American Scientist* (bimonthly). $$

**Description:** This journal is published by Sigma Xi, The Scientific Research Society. It has a variety of papers from social, physical, and biological sciences. We recommend this journal particularly because of regular contributions by Henry Petroski. In 1992 and 1993, these pertained to the history of engineering (and hence to theme 2).

**Source:** Sigma Xi, The Scientific Research Society, P.O. Box 13975, Research Triangle Park, NC 27709; (919)549-4691.

106. *Bulletin of Science, Technology, and Society* (bimonthly). $$

**Description:** This journal contains articles on STS topics, as well as teaching materials. Although the teaching ideas are targeted primarily at post-secondary educators, many of the ideas are also useful at the secondary level. Book reviews are provided in each issue.

**Source:** STS Press, Materials Research Laboratory, University Park, PA 16802; (814)865-1137.

107. *Hastings Center Report* (six issues annually). $$

**Description:** Ethical issues in medicine and the life sciences are the focus of this journal. In addition to several articles, most issues contain a brief case study with reactions from experts with different views on the case; the cases are brief enough to be read and discussed with secondary students.

**Source:** Hastings Center, 255 Elm Road, Briarcliff Manor, NY 10510; (914)762-8500.

108. *Journal of Research in Science Teaching.* $$$$

**Description:** The articles in this journal typically describe the results of research and evaluation studies. We recommend it particularly because of a paper by Norman Lederman in the April 1992 issue. The article is titled "Students' and Teachers' Conceptions of the Nature of Science: Review of the Research." This review will interest teachers who design alternative assessments for their students and are interested in students' conceptions of science.

**Source:** Journal of Research in Science Teaching, 605 Third Avenue, New York, NY 10158; (212) 850-6645. (Available at University libraries)

109. *Magazine of History for Junior and Senior High School Teachers* (quarterly). $

**Description:** This journal contains articles and teaching activities on a variety of topics in history, particularly U.S. history. Each issue has a theme, such as teaching about religion, the Progressive Era, Reconstruction, and the West.

**Source:** Organization of American Historians, 112 North Bryan Street, Bloomington, IN 47401; (812)335-7311.

110. *SHiPS Teacher's Network News: A Newsletter for the Sociology, History and Philosophy of Science in Science Teaching* (Triannual). $

**Description:** This newsletter typically has descriptions of lessons submitted by teachers or biographical information about scientists, sources of reference material, and news about history of science conventions. Permission to photocopy the materials is included, as long as the source is credited.

**Source:** SHiPS Editor, 579 Ashland Avenue, St. Paul, MN 55102; no phone number available.

111. *Technology and Culture: The International Quarterly of the Society for the History of Technology.* $$

**Description:** This scholarly journal presents articles and book reviews on the history of technology. In addition to providing good background reading for teachers, many articles could also be used as the basis for developing student readings on various technologies.

**Source:** University of Chicago Press, Box 37005, Chicago, IL 60637; (800)621-2736.

APPENDIX

# Background on Selected Teaching Strategies

As you implement or develop HNST lessons and units that actively involve students in constructing their understanding of the HNST themes, you may find that you need to use some new teaching strategies. This appendix provides background on a range of strategies embodied in the lessons presented in Chapter 4. Some of these strategies may be new to you and some will likely be quite familiar. We hope this information will be useful in using the lessons we have provided, as well as in thinking through the learning experiences you plan for students when you develop HNST lessons or units.

This appendix is by no means exhaustive. Many other teaching strategies not represented in the lessons presented in Chapter 4 would also be effective in teaching about the history and nature of science and technology, including reenactments of historic events or impersonating famous scientists, story-telling, field experiences, and the like. Our purpose in providing this chapter is to help you use the lessons in Chapter 4 effectively, not to provide an overview of all the relevant teaching strategies. In selecting from the vast range available, we would simply remind teachers that learning is a process of constructing understanding and that individuals learn most effectively in different ways. Selecting varied teaching strategies that actively involve students in constructing their understanding will thus enhance learning for all students.

## Brainstorming

Brainstorming is the process of generating as many alternative suggestions as possible to fit a given situation. The brainstorm is a useful technique in the engage portion of a lesson because all students, regardless of level of academic achievement, can participate equally. It is nonthreatening because no evaluation is allowed, and it does not require prior preparation. In addition, a significant amount of information can be gathered quickly.

A critical concern, of course, has to do with what one chooses to have a class brainstorm about. The question should be clearly stated. It should be one for which there are multiple possible answers. Students should be able to generate ideas without extensive background knowledge. For example, displaying a technological artifact from another culture and asking students to brainstorm possible uses would be an appropriate brainstorming task, while asking them to brainstorm possible effects of the Industrial Revolution on Japanese culture at the beginning of a unit on the Industrial Revolution would not.

Specific rules for the brainstorming process (see box below) should be shared and discussed with students before a brainstorming session begins. Allow students to call out their ideas without having to be recognized. All ideas should be posted without evaluative com-

### Rules of Brainstorming

1. Say anything that comes to mind.
2. Piggybacking on the ideas of others is good.
3. Don't evaluate or criticize what others say.
4. When you can think of anything else, wait a minute and try again.

ments or editing. Critical comments can too often prevent creative, but risky, suggestions from being presented. The teacher can often stimulate a stagnant session by proposing truly outlandish ideas.

Another way to encourage creativity is to use the SCAMPER technique (see box below). In this technique, students reexamine and apply each of the SCAMPER elements to the ideas already suggested.

### The SCAMPER Technique

S = substitute, subtract
C = combine
A = adapt, add
M = modify, minify, magnify
P = put to other uses, piggyback
E = eliminate
R = reverse

The debriefing of a brainstorm should focus on the use of the ideas within the context of the teacher's purpose in conducting the brainstorm. For example, if the purpose of a brainstorm is to make students aware of how technology affects their lives, the debriefing might focus on the sheer number of items generated and their collective impact on students' lifestyles. On the other hand, if the purpose was to generate ideas for student exhibits at an HNST Expo, some evaluation of ideas using specific criteria related to suitability for research might be in order during the debriefing.

Lessons B, G, I, and J provide examples of the use of brainstorming in HNST lessons.

## Voting with Your Feet

The purpose of the human continuum strategy is to have students choose positions on an issue, defend those positions, and listen to other viewpoints. The strategy allows for greater kinesthetic activity than most issues-based discussions, which gives some students greater freedom to express themselves. The strategy also reinforces the idea that it is okay to change your mind. It is a useful engage activity for lessons in which students explore ethical or value issues; returning to the activity following the lesson can be an effective way to encourage students to reflect on their learning (the evaluate portion of the lesson).

To use the activity, define the issue to be discussed in such a way that there are two clearly conflicting options to be considered. Write each position on one end of a long line you have drawn across the chalkboard. For example:

| | |
|---|---|
| Scientists today should not use Nazi data under any circumstances. | Scientists today should use Nazi Nazi data if it helps advance knowledge. |

Open the discussion by presenting the issue. Then tell participants that they are going to express their opinions on the issue by voting with their feet. Ask participants who agree with the statement at one end of the continuum to come to the front of the room and stand by the statement; those who agree with the other statement should stand at the other end of the continuum. Those who have positions between the two extremes should position themselves along the line to show their relative disagreement/agreement with the two statements. For example, someone who thinks that Nazi data can be used if the scientist includes a disavowal of Nazi methods might position himself/herself near the midpoint. People who do not know what their position is can stand in a location off the line.

Ask for a volunteer near one end of the line to explain his/her position; allow time for someone with the opposing view to respond. Then allow participants to question each other regarding their positions. It is a good idea to have some probe questions prepared in case participants do not come up with questions or comments quickly. A strategy that is often helpful is to ask the people in the "Unsure" category what they need to know before they can decide which position they would support. It is important that students understand that they can change their vote at any time by moving along the line. Point out that remaining open-minded while listening to the various positions will allow students to cast more informed votes.

Continue the procedure until the comments appear to be winding down. Allow students to return to their seats. As an evaluation of how well students listened to each other, you might ask them to briefly describe the most effective arguments they heard on behalf of each position.

Lesson A provides an example of how this strategy can be used in an HNST lesson.

## Using Artifacts

An artifact is an object produced by human workmanship. To be considered an artifact, an object must be of historical or archaeological interest. Artifacts can make history of technology lessons meaningful and memorable for students of all ages, and particularly so for kinesthetic and visual learners. They are especially useful in the engage and explore portions of the lesson.

Artifacts are, however, only as effective as the strategies teachers employ for their use. Use of artifacts as a "teacher's show and tell" makes them no more effective than an illustrated lecture.

Artifacts are most effective when students can touch or hold them. Students who are using artifacts for the first time might simply be asked to look at an article to determine what it is. This may be a special challenge when dealing with historical items that have no contemporary analogs. Encourage students to examine any writing on the object, to determine what the object is made of, and to see how the parts of the object work together. All of these can provide clues to the object's function. It may sometimes be impossible to determine what an object was used for; while this may be frustrating to some students, it also opens up their thinking to more possibilities.

Examination of a collection of items can be organized as a scavenger hunt. Give students a list of items to find, such as:

- Find a technology made completely of wood.
- Find a technology that you think was used in the kitchen.
- Find a technology that would be fun to play with.
- Find a technology that employs a pulley.

A variety of artifacts can be useful in encouraging students to draw conclusions about a society or industry that used the artifacts. Students could make inferences about the values of a culture using several technological artifacts.

Artifacts may be borrowed from local museums, historical societies, or organizations devoted to particular hobbies, such as railroads. Some replicas or originals may be obtained from antique shops, auctions, or science supply companies. Many teachers collect artifacts in their travels. You may want to supplement your artifact collection by obtaining books that illustrate other examples of the artifacts you wish to show.

Students can also be a source of artifacts. They can simply be asked to bring in relevant technologies. Alternatively, students can be given an assignment to create an artifact kit on a particular HNST topic. The kits could be expanded to include other kinds of primary sources, as well as replicas of devices for which students cannot find authentic originals. Creating such kits can be a rich and rewarding learning experience.

Lesson I is an example of how artifacts can be used to develop understanding of the HNST themes.

## Role Plays and Simulations

Role playing can be an effective technique for focusing on the process of decision making and alternatives for conflict resolution. Role playing also enables students to explore other points of views.

Successful role playing depends on the establishment of a genuinely receptive atmosphere, based upon the teacher's belief that all individuals have the capacity to solve their problems. To maintain this atmosphere, students should be permitted to make mistakes and learn from them.

The peer group can also affect the success of role playing. Too often, young people are stereotyped by their classmates in a way that tends to be self-fulfilling or stifling in a role-playing situation. Students should not be assigned roles that have characteristics similar to their stereotypic classroom images.

Don't be discouraged if role playing appears to fail the first few times your students try it. Everyone tends to be uncomfortable with a new strategy, and role playing is one of the more demanding ones. Students will likely demonstrate this discomfort either by acting silly or by being unwilling to participate. They need a lot of support and encouragement in the beginning. Initial role-playing activities should be simple, but they should become increasingly more complex if role playing is to be more than an exercise in dramatics.

Below are some guidelines to follow in using a role play:

- Present the problem or situation. Be sure to give students adequate information to play their roles convincingly. Specify how much elaboration of the roles is expected/acceptable.
- Assign roles or solicit volunteers. An entire class may participate even if there are only two roles. Arrange the students in pairs or use trios, with the third student acting as observer.

- Get the class involved as quickly as possible. Don't spend too much time on the introduction.
- Role reversal can be a useful device when students appear unsympathetic to the opposing viewpoint or when a student has been stereotyped by peers.
- Vary role-playing activities. Students will tire of the same routine.

Discussion of the role play should either be integrated with the activity or follow it immediately. Any significant lapse of time between role playing and the debriefing will dilute the value of the activity. The following questions may be useful in focusing the follow-up discussion:

- Were the plays realistic?
- Was the problem solved? If so, how? If not, why not?
- What were the alternative resolutions?
- Is this situation similar to anything you have personally experienced?
- How did you feel playing the role?
- If you repeated the role play, would you do anything differently?

Role plays are often a component of simulations, which allow students to experience vicariously a process that might otherwise be inaccessible to them. Simulations also allow students to experience processes and situations without risk. Students can practice decision making and even make mistakes in judgment without suffering serious consequences.

Simulations are especially effective in recreating the process used in making decisions, either in history or currently. Special types of simulations that are appropriate for HNST classes are mock trials, moot courts, or mock legislative hearings. Business simulations are also useful.

Note that simulations usually involve both role playing and small-group work. If students do not have experience with these techniques, teachers would be wise to do some role plays and small-group exercises before attempting a simulation.

Simulations seem to run more smoothly if the following stages are used:

**Preparation.** Break the simulation down by outlining the steps and allocating time periods for each. Organize the classroom to suit the simulation, including rearranging furniture if necessary.

**Playing.** Introduce the simulation briefly by outlining the rules and/or procedures. All students should have some assignment in every part of the simulation. For example, in a mock trial, all students may assist in the preparation of the cases, but there may not be enough active roles in the trial for everyone. Those students not participating should be asked to observe for specific criteria or to act as reporters, observing and writing stories or preparing newscasts following the trial.

**Debriefing.** This usually consists of a follow-up discussion or other technique that helps students absorb and analyze what has happened. It is the most important stage of the simulation. First, the room should be rearranged in its usual setting. Second, a short one-page worksheet with questions designed to elicit reactions about the simulation will help to focus the discussion. It also helps to calm everyone down after what can sometimes be a chaotic and noisy experience. Then conduct small- and large-group discussion, using questions that isolate the purposes of the simulation. Be sure to relate the simulation to students' previous learning.

A few precautionary notes are in order. Some simulations require extensive teacher preparation. Teachers must ask themselves: "Is it worth it?" Competition is involved in some simulations. Teachers should be sure that students understand the purpose of the simulation and that "losing" the simulation does not mean students learned less or were less successful. Finally, students may view simulations as unrealistic, and some of them are. Teachers should try to relate the concepts and principles of the simulation to real-life experiences.

A special form of simulation is the computer simulation. The computer can make simulations more realistic and effective by providing increased sophistication, access to databases, inclusion of random events, branching, and reinforcement.

Lesson D in Chapter 4 provides an example of how to use a computer simulation to develop HNST understandings; Lesson F is an example of a historical decision-making simulation.

## Using Community Resources

Involving community resource people in your classroom can lend authenticity to many areas of study. Because science and social studies often interface along

public policy issues, the use of resource people may be particularly appropriate in these courses.

Community resources can be useful at any stage of the instructional model, depending on how you use their talents. Some possibilities include the following:

- Participating in a panel discussion.
- Taking part in a debate.
- Debriefing a video or other activity.
- Participating in a role play or mock trial.
- Coaching students.
- Conducting a demonstration.
- Being interviewed by students.

Encourage the resource person to involve students actively. The tools of the resource person's profession may be especially fascinating to students. Also encourage the resource person to connect his/her work to students' lives and to let the students know that he/she is a "real person" with a family life, outside interests, etc.

Make the outside resource person aware of what the students are studying, what their age range is, their level of knowledge about the topic or theme they are studying, and any disabilities the students have that might affect the style of the presentation or the activity. It is also helpful for a visitor to know the size of the room, what laboratory facilities are available (as appropriate), and the length of time allotted. The following checklist for resource people may also be helpful.

**Do:**

- Consider the age and experience of the audience. Use appropriate vocabulary.
- Maintain eye contact.
- Solicit feedback frequently. Ask questions and give time for students to think before anyone answers.
- Encourage active participation early and throughout the presentation.
- Be yourself; let your personality show; be real; smile.
- Call on a variety of students and involve the teacher.
- Circulate around the room.
- Make sure that everyone hears all questions and answers.
- Know the objectives for your visit and how it relates to what students are learning.
- Link your subject to students' lives.

**Don't:**

- Lecture at students.
- Use jargon or highly technical language.
- Act condescending or omniscient.
- Become angry at heckling or unresponsiveness.
- React defensively to criticism.
- Read a prepared speech.
- Talk in a monotone.
- Assume that students either have or lack knowledge about a given point.

Some typical sources of community resource people include:

- Museums.
- TV stations (for example, meteorologists).
- Retirement association volunteers.
- Local companies, including utility companies.
- Professional associations (for example, bar associations, organizations of geologists or engineers, investors clubs).
- Local colleges and universities.
- Government agencies.
- Health care facilities.

Utilizing community resources can also mean taking advantage of opportunities for field experiences at manufacturing plants, museums, zoos, parks, or laboratories. Field experiences can make what students are learning in class more concrete and real. When planning such a field trip, establish who your contact people are; find out how large a group can be accommodated; how far a visit must be scheduled in advance; the cost, if any; and what format the site visit will follow, in terms of length, intended audience, and activities.

Before embarking on the field experience, prepare the students. Be sure that they understand the objectives of the field experience and how it fits into the HNST unit. Provide guidance if you want students to gather data through fieldnotes, photographs, or other means.

Be sure to allow time after the field experience for class discussion and follow-up. Examine with students what they observed and learned, how it relates to the history and nature of science and technology, and what questions remain to be answered. Follow-up visits or interviews, exhibitions of pictures taken on the trip along with other information gathered, or independent investigations can extend the learning.

While none of the lessons in Chapter 4 explicitly call for the use of community resources, several could be enhanced by their use. For example, a genetic counselor could assist in debriefing Lesson J; following Lesson D, students might interview inventors to see how the process they use in developing and testing new ideas is similar to and different from the process students used in the lesson.

## Design/Invention Activities

Design/invention activities are particularly appropriate in the study of technology. Such activities work well in either the explore or elaborate portions of lessons.

In design/invention activities, students are asked to create something that fills an unmet need or meets the need in a new way. In some activities (as illustrated by Lessons B and D in Chapter 4), the teacher may assign a particular need that all students are to address. In other activities, students may have the freedom to choose a need they wish to address.

The standards the invention is to meet are generally established in advance; these standards may be relatively rigorous (as in Lesson D) or fairly general (Lesson B). Criteria for evaluating the inventions may be inherent in the standards, but students may develop additional criteria as they create their inventions and analyze inventions created by other students. For example, students may not think of the aesthetic dimension until they have seen a particularly attractive invention; they may not think about feasibility questions until they have experienced the difficulty of building a device in the way they designed it.

Design/invention activities often work best when conducted in pairs or small groups (three or four members). The process often begins with brainstorming or simply "playing" with the available materials. The next step is to create a rough sketch or plan. At times, the teacher may want to stop the activity at this design stage. In other instances, students will actually create a model of the invention, which is tested, revised, and polished.

Invention and design are among the most creative activities in which students can be involved. Invention activities are especially useful in exploring the technological process, learning about the criteria by which technological devices are evaluated, and developing understanding of the interrelations between technology and culture.

## Oral History

Oral history is the process of collecting information through tape-recorded interviews with people who have firsthand knowledge of particular past events or issues. Conducting oral histories is an effective way for students to elaborate their understanding of the impact of science and technology on people's lives, with particular focus on the effects on the local community. It also develops a broad range of skills, including speaking, listening, and analyzing.

Before a teacher undertakes an oral history project, students need background information on the era or topic to be explored. Some of this information can be gained through reading other oral histories, which will acquaint students with the form of oral histories and provide a basis for later substantive comparison with the recollections of their interviewees.

A second useful preparatory step is demonstrating the oral history process by conducting an oral history interview in class. Students can help prepare for the interview by determining the purpose of the interview, generating questions that will tap into the knowledge of the interview subject, and creating follow-up questions to keep the memories flowing. Tape record the interview as you conduct it. You may then spend a follow-up period analyzing the tape; this will be especially valuable in illustrating how careful listening to the responses can help the interviewer revise or create new follow-up questions. Don't be afraid to point out instances in which a better follow-up question would have elicited more information.

Before students embark on their own interviews, acquaint them with the general guidelines for conducting an interview given in the box below. Be sure all students have access to adequate tape-recording equipment.

Until students have some experience with oral history, it is a good idea to work as a class to determine the purpose of the interviews and generate possible questions or topics for inquiry. Students may feel more comfortable conducting their first interviews with relatives or close acquaintances. Even role playing interviews with classmates may be good preparation for some classes. Sources for interviews include the local historical society, articles in the local newspaper, nearby colleges or universities, senior centers, and local chapters of such organizations as the VFW, NAACP, DAR, or Gray Panthers.

Following the interviews, students should analyze the information gathered, using such questions as:

- How reliable is the memory of my interview subject?
- Into what context—local, national, or international—does this interview fit?
- How do this person's recollections/opinions fit with those of others who were interviewed? with information from other sources?

The tapes created by the students can become part of a school oral history library on which future classes can draw in conducting such projects.

Lesson G suggests oral history as one strategy students might use in their small group research. Oral history could also be an effective way for students to further elaborate what they learned about the impact of the automobile in Lesson E.

### Guidelines for Conducting an Oral History Interview

1. Pick a quiet place in which to conduct the interview.
2. Ask the person you are interviewing to sign the release.
3. Test your equipment before you begin the interview.
4. At the beginning of the tape, state your name, the name of the person you are inverviewing, and the date.
5. After the interview, label each tape with your name and the subject's name, the date, and the number (if more than one tape).

## Conducting Surveys

The survey, a tool of social scientists in several disciplines, can also be used as a teaching strategy. Students can use surveys of public opinion as a tool to elaborate their understanding of conflicting views on ethical issues and of the role of public opinion in shaping policy. A survey can be taken within the school or in the larger community. Such an activity will not only expand students' thinking on a particular topic, but also develop their information-acquisition skills.

The topics on which students are seeking information should not be too broad ranging. A brief survey is preferable to a lengthy one. Students will find it easier to interpret data using questions with a limited number of possible responses.

A specific number of people to be surveyed should be assigned each student. Students should be briefed on survey etiquette. Potential respondents should be approached politely and asked if they would have time to respond to a brief survey; the purpose should be explained in a few words. If someone says "no," students should not try to change their minds. Those who consent should be thanked.

Students should analyze the data and be encouraged to present their findings in a variety of ways. Also encourage them to consider the limitations of their data. Comparing this process with the ways in which scientists in the life, earth, and physical sciences gather and interpret data will be a useful reflection on the nature of science. The cooperation of the math teacher in analyzing data may be helpful, though probably not necessary.

Lesson G suggests the use of a survey as one research technique for small groups of students. A survey of energy use could also be a useful follow-up to Lesson B.